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JOURNAL OF DAIRY SCIENCE

OFFICIAL ORGAN OF THE
AMERICAN DAIRY SCIENCE ASSOCIATION

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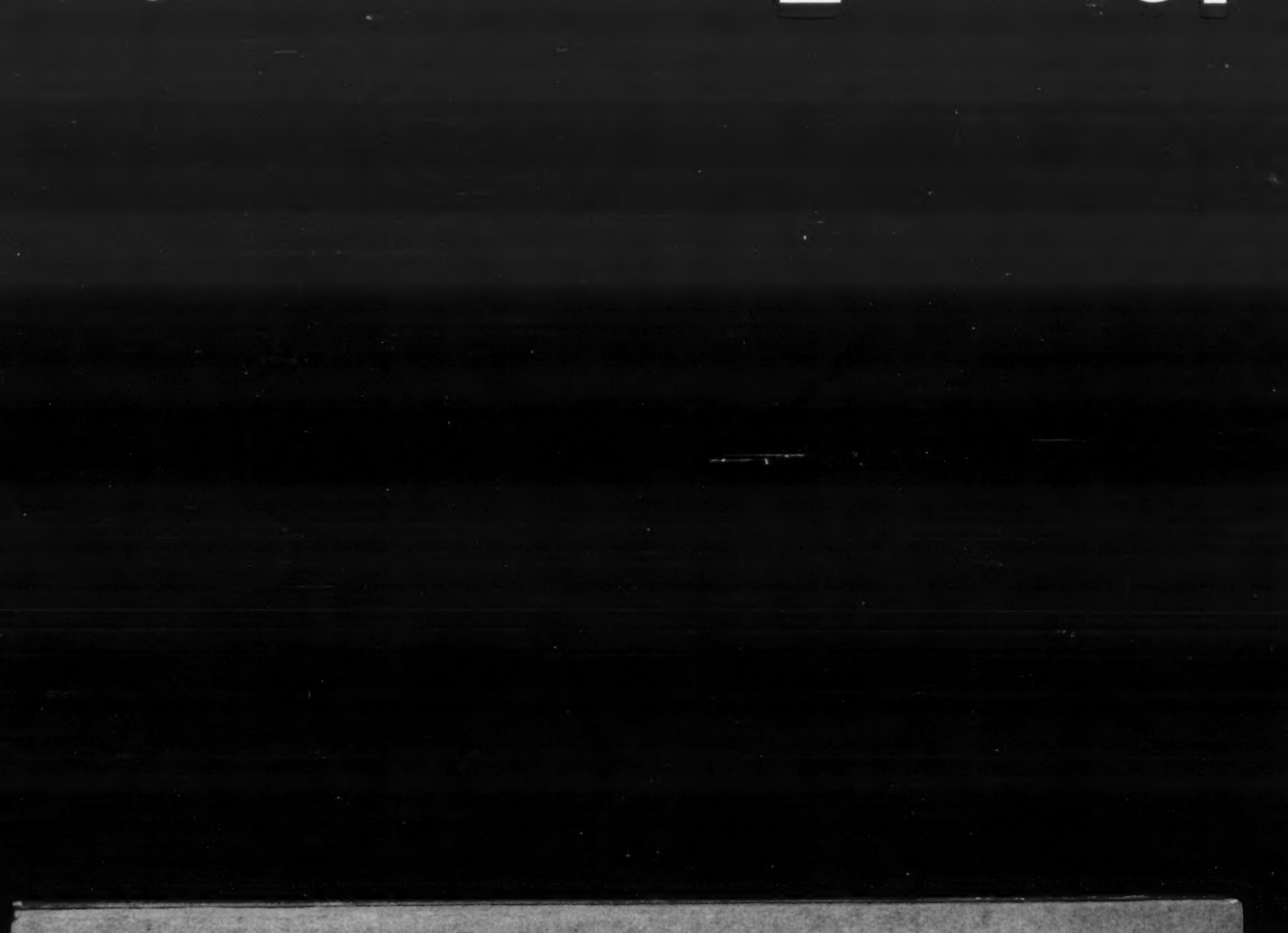

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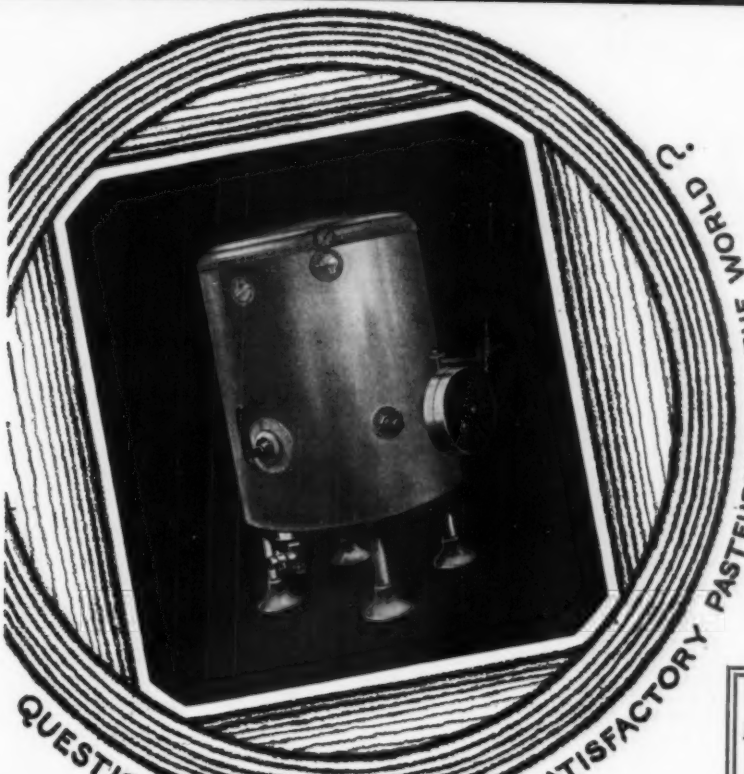

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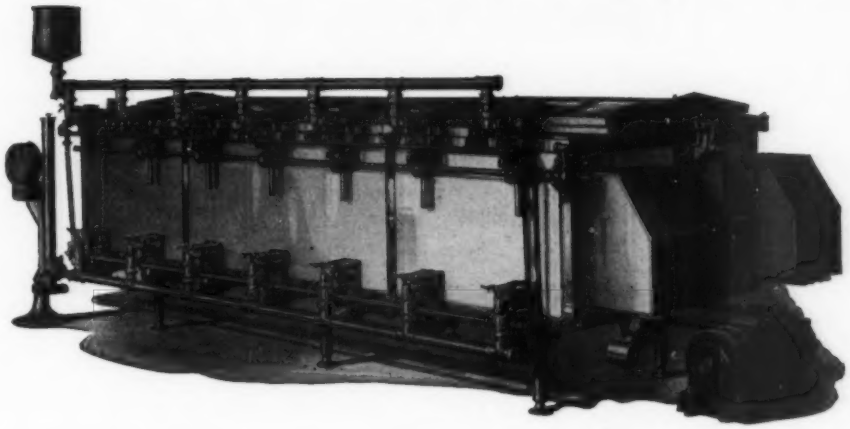

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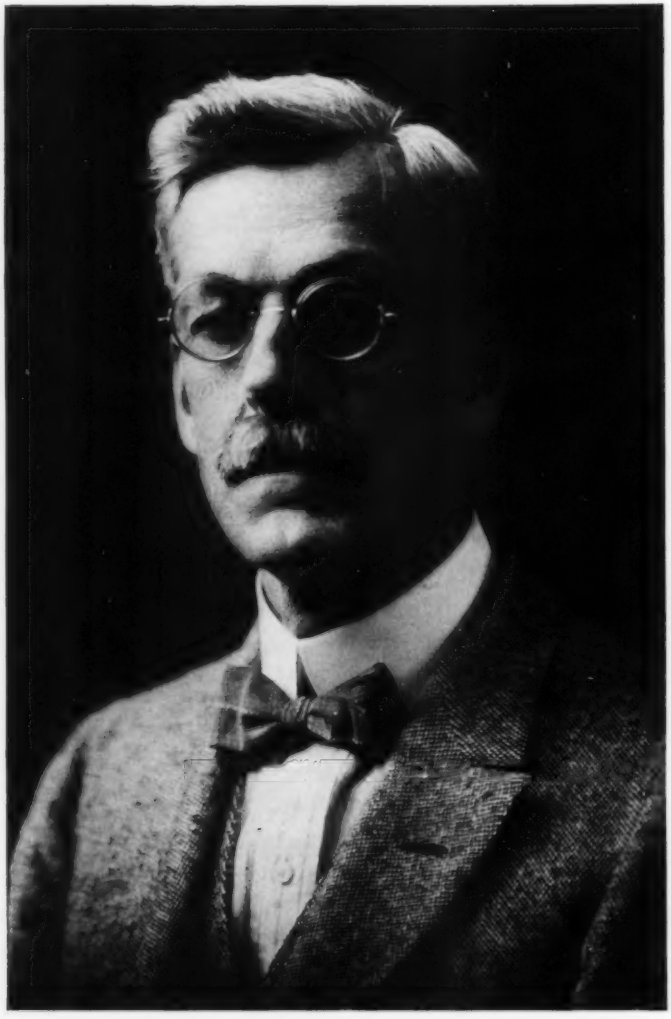
J. H. FRANDSEN, *Editor*



William Alonzo Stocking, Jr.

WILLIAM ALONZO STOCKING, JR.

William Alonzo Stocking, Jr., was born May 13, 1872, on a farm near the town of Simsbury, Connecticut. His parents were William A. and Serinda (Delanoy) Stocking. He married Harriet M. Bliss of Binghamton, N. Y., on June 27, 1900. The widow and their four children John, Robert, William and Elizabeth, all survive their husband and father, who died February 3, 1926, at his home on Cayuga Heights, Ithaca, N. Y.

Professor Stocking graduated in 1895 from the Connecticut Agricultural College (Storrs) with the degree B.Agr. and three years afterward received the B.S.A. degree at Cornell University. He acted as Instructor in Agriculture at the Mansfield (Penn.) Normal School during the academic year 1898–1899, after which he returned to the Connecticut Agricultural College as Assistant Professor and later as Professor of Dairy Bacteriology. He remained at Storrs until 1906 when he received an appointment as Assistant Professor of Dairy Bacteriology at the New York State College of Agriculture at Ithaca. Meanwhile (1904) he had received the M.S. degree from Cornell University.

In 1909 at the time when Professor R. A. Pearson left to become the Commissioner of Agriculture of New York State, he was given a full professorship at Cornell and was appointed head of the Department of Dairy Industry. During 1913 and 1914, after the resignation of former Dean Liberty Hyde Bailey, Professor Stocking was Acting Director of the College of Agriculture and of the Cornell Agricultural Experiment Station. He resigned his responsibility as head of the Department of Dairy Industry on June 14, 1923, continuing the duties of Professor of Dairy Bacteriology until November 1925, when his illness compelled him to stop work.

Such is the simple biographic and academic record of a man who has been one of the leading contributors to the scientific development of the dairy industry in the United States of America.

Professor Stocking was one of the earliest workers in the field of dairy bacteriology to undertake the evaluation of the importance of the various sources of bacterial contamination of market milk. This work was done at Storrs. It included a survey of the results actually being obtained on a series of dairy farms and a study of the effect of covered pails, of feeding dusty feeds, and of cleaning cows, upon the bacteria count and dirt content of milk. Likewise, he was the first to make exhaustive study of the causes of the excessive contamination of milk where milking machines were used and through his efforts American manufacturers were aided in putting really successful milking machines on the market. His report on methods of sterilizing milking machine tubes contains the first detailed bacteriological report on the method of placing the tubes in brine, a method which today still is regarded as one of the most useful that has been suggested.

He likewise took part with Professors H. W. Conn and W. M. Esten in the pioneer study of the bacterial species found in dairy products, the final report on this work appearing in the 1906 Annual Report of the Storrs Station. He also shared in the studies of foreign type cheeses, particularly Camembert, which were undertaken under the leadership of Professor Conn.

A heavy burden of teaching and later of administrative responsibility fell upon Professor Stocking during his later years in Ithaca so that, to his deep regret, he was unable to maintain his investigational work. Many a young man felt his guiding hand and today his students are to be found in many places in the dairy industry where a scientific training is necessary for the greatest success. His influence will abide through the constructive work that these men are doing.

During this period he prepared the fine discussion of the types of bacteria found in dairy products which appeared as a section of Marshall's Microbiology, and wrote a "Manual of Milk Products" a book widely used as a text in agricultural colleges. His influence was widely felt throughout the dairy industry of the State and of the Nation. This influence was especially evidenced through his activities in connection with Farmers' Week programs, membership in the New York State Agricultural Society

and the New York State Dairymen's Association. He was particularly active in the latter association and served as its President from 1922 to 1924.

Professor Stocking was interested in the formation of the National group of dairy instructors into the Official Dairy Instructors' Association in 1906. He continued his active interest in this Association when it broadened its field of work and became the American Dairy Science Association. He served as President of this Association from 1916 to 1918, and as a member of many of its important committees. He was a member of the editorial board of the JOURNAL OF DAIRY SCIENCE from the time of its foundation by this Association in 1917.

The splendid dairy building of the College of Agriculture, dedicated at the time of the World's Dairy Congress in 1923, will remain as a fitting memorial to his untiring efforts for the advancement of dairy science in America. Upon his retirement from the administrative responsibilities of the Department of which he had been the head for so many years, he took particular delight in renewing his interest in the Society of American Bacteriologists of which he had been a member since 1912, attending the National meetings of this society in 1923 and 1924 and taking an active interest in maintaining the work of the Central New York Branch of this Society. In April 1924 Professor Stocking represented Cornell University and the United States Department of Agriculture at the International Dairy Exposition in Milan, Italy, and studied the dairy industry in Italy, Switzerland, France, Belgium, Holland and England.

In addition to his connection with the New York State College of Agriculture as a student, Professor Stocking served on the Staff through twenty years that are particularly significant because they constitute the period in which the broad policies of the institution have been cast. Professor Stocking was an active member of that earlier group that gave character and strength to a vigorously growing institution. To his special credit must be placed the development of dairy industry as a large and strong unit in the college organization. He will be sadly missed by his old associates, most of all because of the kindly spirit that pervaded all of his relationships.

In these days when there are many who fail to appreciate the fact that true science and true religion should work together harmoniously in their search after the truth that endures, it may be well to record also that Professor Stocking was active in the First Presbyterian Church of Ithaca, serving on the session of this church for eleven years. He was sincere in his love for his fellowmen and his purpose to help them, ever ready to go out of his way to do the thoughtful thing and say the gracious word. He bound men to him in abiding friendships. His spirit was broad and tolerant. He had profound convictions and held himself rigidly to them, but was ever charitable in his judgment of others. He gave the impression of singular gentleness, a life from itself set free. He leaves with those who came into contact with him only memories which strengthen faith in things which give hope and dignity to the meaning of human life.

E. S. Guthrie and R. S. Breed.

THE COMPOSITION, DIGESTIBILITY AND FEEDING VALUE OF HYDROLYZED SAWDUST*

J. G. ARCHIBALD

Massachusetts Agricultural Experiment Station, Amherst, Massachusetts

This investigation was undertaken at the instigation and with the coöperation of the Forest Products Laboratory of the United States Department of Agriculture, located at Madison, Wisconsin. Sherrard and Blanco (1) of that laboratory have carried on extensive experiments in the conversion of the woody fiber of the sawdust from several species of wood, into a more soluble form for the production of industrial alcohol, and as a possible source of cattle food.

The method of treatment consists in cooking the sawdust under 120 pounds pressure with dilute sulphuric acid, which converts a portion of the cellulose and allied substances into sugar. The liquor resulting from the digestion together with the washings from the undigested sawdust residue is neutralized with lime and evaporated to a thick syrup, which is mixed with the dried residue. The product is then ready for feeding. It is a dark brown somewhat powdery meal with a slightly sweet woody odor and a woody flavor.

Its feeding value was investigated first by the Animal Husbandry Department of the Wisconsin Agricultural Experiment Station (2) and later by the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture, at its experiment farm in Beltsville, Maryland (3). The results of these trials were somewhat conflicting, hence the request from the Forest Products Laboratory to this station to coöperate in carrying on further investigations.

* Received for publication November 30, 1925. Published with the joint permission of the Director of the Massachusetts Agricultural Experiment Station and the Forester, Forest Service, United States Department of Agriculture.

Our work on the product has been divided into four phases:

1. Determination of its proximate composition
2. A preliminary palatability test
3. Determination of its digestibility
4. Its feeding value for milk production

TABLE 1

Proximate composition of hydrolyzed sawdust

LABORATORY NUMBER	MATERIAL	WATER AS RECEIVED	DRY MATTER BASIS				
			Ash	Protein	Fiber	N-free extract	Fat
728	Hydrolyzed sawdust (Douglas fir)	6.80	2.04	0.05	48.73	47.65	1.53
733	Hydrolyzed sawdust (Douglas fir)	7.43	2.24	0.00	48.68	47.83	1.25
740	Hydrolyzed sawdust (Douglas fir)	7.09	2.75	0.15	46.63	49.40	1.07
769	Hydrolyzed sawdust (Douglas fir)	6.33	2.45	0.80	46.21	49.29	1.25
790	Hydrolyzed sawdust (Douglas fir)	7.45	3.42	0.15	42.82	52.13	1.49
830	Hydrolyzed sawdust (Douglas fir)	7.50	2.39	0.74	45.43	48.94	2.50
842	Hydrolyzed sawdust (Douglas fir)	7.40	2.55	0.31	46.44	49.31	1.38
856	Hydrolyzed sawdust (Douglas fir)	7.33	2.56	0.12	45.03	50.15	2.15
Average		7.17	2.55	0.29	46.25	49.34	1.58
828	Hydrolyzed sawdust (Eastern white pine)	6.24	3.30	0.42	49.70	43.73	2.85
859	Hydrolyzed sawdust (Eastern white pine)	6.22	3.95	0.50	45.04	48.02	2.49
889	Hydrolyzed sawdust (Eastern white pine)	4.08	2.38	0.51	47.65	44.93	4.52
893	Hydrolyzed sawdust (Eastern white pine)	4.06	2.70	0.36	47.55	45.46	3.93
900	Hydrolyzed sawdust (Eastern white pine)	4.72	3.10	0.60	47.30	45.43	3.57
Average		5.06	3.09	0.48	47.45	45.51	3.47
862	Residue from hydrolyzed Douglas fir	20.36	0.36	0.50	60.73	36.25	2.16
863	Residue from hydrolyzed Eastern white pine	4.58	0.23	0.90	59.91	34.94	4.02
871	Residue from hydrolyzed Eastern white pine	4.40	0.48	0.69	60.23	34.91	3.70
Average		4.49	0.36	0.80	60.07	34.93	3.86

PROXIMATE COMPOSITION

This was determined by the usual methods of fodder analysis.[1] Table 1 presents the detailed analyses.

[1] Acknowledgment is made in this connection of the services of Messrs. P. H. Smith and F. J. Kokoski, who performed all of the analytical work.

As would be expected the product is almost entirely carbohydrate in nature, the crude fiber and nitrogen-free extract constituting on an average about 95 per cent of the total dry matter. Of the nitrogen-free extract, a considerable portion is sugar, according to Sherrard and Blanco (1) about 21 per cent of the original sawdust being converted into sugar by the process. The balance of the nitrogen-free extract is probably largely composed of lignin. The crude fiber is principally crude cellulose admixed with some lignin. The protein moiety is practically negligible, especially so in the case of the Douglas fir sawdust, while the fat is not true fat but resinous matter. The ash is chiefly an additive component, consisting for the most part of calcium sulphate formed by the neutralization with lime of the sulphuric acid used in the process. Laboratory Nos. 862, 863 and 871 are samples of the sawdust residue, with which, at the special request of this department, the syrup containing the sugar produced by the hydrolysis, was not mixed. The reason for investigating these residues is given in the section on digestibility (see p. 260). The main differences in composition between the residue and the complete hydrolyzed product are seen in a higher crude fiber content and a correspondingly lower amount of nitrogen-free extract, due to the removal of the sugar-holding liquor by centrifugation and washing. The ash content is that of the natural wood.[2]

PALATABILITY

The first step in the investigation was to determine if cows would eat the sawdust. Eleven animals in the station herd in groups of two at a time were offered the material as a supplement to their grain ration in amounts not exceeding 5 pounds daily, for periods varying with the different individuals from one to four months. Ten of the cows ate the sawdust, when moistened and mixed with their grain, with no apparent ill effects. Eight of them showed no dislike for it when fed in this way. All the cows refused it when it was fed alone, even when placed before

[2] For a more detailed study of the composition of the material the reader is referred to the work of Sherrard and Blanco.

them previous to the regular grain feeding. The Douglas fir sawdust was the kind used for this test. The maximum amount that a cow would consume without waste was 4 pounds daily.

DIGESTIBILITY

Commencing in June, 1924, and ending in February, 1925, 6 digestion experiments with 3 sheep in each, i.e., 18 single digestion trials were carried on. Each of these experiments was of sixteen days duration and the materials investigated were: hydrolyzed Douglas fir sawdust, hydrolyzed Eastern white pine sawdust, and the residue from hydrolysis of Eastern white pine sawdust. The digestibility of this residue minus the liquor was determined to check up the assumption that it is probably without food value, the reasoning being that if it proved to be valueless why use it, or so much of it, as an absorbent for the liquor? Why not use as an absorbent some material having food value in itself?

A uniform ration was fed to the sheep throughout all the experiments. It consisted of:

	Grams daily
Hay	400
Gluten feed	125
Hydrolyzed sawdust	100
Salt	10
Water ad libitum	

The digestibility of the basal ration, consisting of hay and gluten feed was first determined by feeding these to the same sheep in a digestion trial identical with those in which the sawdust was added to the ration.

In all cases the sheep ate their daily allowance without waste, although they showed some reluctance about eating the *residue* from hydrolyzed Eastern white pine sawdust. No digestive disturbances were noted when the Douglas fir and Eastern white pine sawdust were fed, but when the *residue* from the white pine was fed there was marked disturbance as evidenced by the condition of the feces which became very soft and bulky.

Table 2 summarizes the results of the work.

DISCUSSION OF RESULTS

a. Douglas fir sawdust. Excluding from the average two

TABLE 2

Summary of digestion coefficients, expressed as percentages on a dry matter basis

	SHEEP	EXPERIMENT	DRY MATTER	FIBER	N-FREE EXTRACT
			Douglas fir sawdust		
I	23	2	31.49	15.09	59.30
II	23	4	48.48	17.63	76.85
III	24	2	35.46	6.76	62.07
IV	24	4	31.83	0.90	64.48
V	25	2	25.48	None	55.71
VI	25	4	32.13	0.52	54.99
Average			34.15	Not averaged	62.23
Average omitting II and V			32.73		60.21
			Eastern white pine sawdust		
I	23	3	46.69	18.72	65.46
II	23	5	44.05	10.87	72.37
III	24	3	44.42	21.03	64.49
IV	24	5	36.45	None	64.47
V	25	3	49.73	24.46	63.34
VI	25	5	27.66	None	52.54
Average			41.50	Not averaged	63.78
Average omitting IV and VI			46.22		66.42
			Residue from hydrolysis of Eastern white pine sawdust.		
I	23	6	1.69	4.25	12.53
II	23	7	13.20	10.89	27.03
III	24	6	22.79	16.55	31.74
IV	24	7	None	None	0.45
V	25	6	32.41	20.58	37.61
VI	25	7	None	None	None
			None of these results can be averaged		

results which deviate considerably from the mean, the dry matter of this material had a digestibility of roughly 33 per cent, which

consisted almost entirely of nitrogen-free extract. The actual amount of nitrogen-free extract digested was equal to 28.5 pounds for each 100 pounds of sawdust (average of four single trials). This is a slight excess over the amount of sugar reported by Sherrard and Blanco (1) as being formed in the process of hydrolysis. It is evident that digestion was confined principally to this soluble carbohydrate, the other constituents being practically unattacked.

b. Eastern white pine sawdust. Excluding here also two deviating results, it is seen that this sawdust contained about 46 per cent of digestible dry matter, approximately 40 per cent more than the Douglas fir sawdust contained. The amount of nitrogen-free extract digested (28.6 pounds per 100) was almost identical with that digested in the case of the Douglas fir, so it is evident that some other proximate constituent must have been utilized to account for the higher total digestibility. Although the coefficients for fiber show a quite low digestibility (24.46 per cent as a maximum) they are somewhat higher than those obtained with the Douglas fir and we must assume that the difference in total digestible dry matter is due to a more digestible fiber in the pine, for by no stretch of either figures or imagination can the small amounts of protein, fat and ash present be made to account for it. The assumption is that in the pine wood the linkage between the cellulose and the lignin is less firm than in the Douglas fir, hence is more readily broken down or sprung apart by the treatment, thus giving the bacteria in the ruminant's digestive tract a better opportunity to act upon the cellulose molecule. It is evident from the wide variations in the digestion coefficients for fiber that the animals experienced difficulty in digesting material of this character.

c. Eastern white pine sawdust residue. A glance at the variable results obtained for this material is sufficient to show that its total digestible matter is so low that it can have no food value whatever. It simply proves the already well-grounded assumption that whatever food value the hydrolyzed sawdust may possess is contained largely in the liquor or syrup produced in the process of hydrolysis.

The white pine residue having given such poor results, it was deemed unnecessary to investigate the residue from Douglas fir, the entire hydrolyzed product from that wood having made a somewhat poorer showing than that from the pine.

Dismissing without further consideration the so-called "residue," it will be well to consider the entire hydrolyzed product from the standpoint of net energy. This station is not equipped for the direct determination of net energy in feeds. There is, however, a fairly reliable formula (4) by which the net energy value of a feed can be calculated if its digestible matter is known, and it is proposed to apply this formula here. Calculated in this manner, the Eastern white pine sawdust has an apparent net energy value of 18.6 therms per 100 pounds, about half that of average quality hay, while the net energy value of the Douglas fir sawdust is a minus quantity, or in other words, more energy is used up in the labor of digesting it than it contains itself.

VALUE FOR MILK PRODUCTION

This phase of the investigation was commenced in October, 1924, and was completed in July, 1925. The kinds of hydrolyzed sawdust fed were the same as used in the digestion studies, viz., Douglas fir and Eastern white pine.

Each kind of sawdust was submitted to an eleven weeks' feeding trial with 6 mature milch cows in the experiment station herd. Each of the eleven-week feeding periods was divided into two four-week periods of actual trial with a ten-day preliminary feeding in every instance, to accustom the cows to the change of feed.

The value of the sawdust for milk production was ascertained by comparison with corn starch, an equivalent amount of each from the standpoint of digestible nutrients being alternately substituted for a portion of each cow's grain for the length of time indicated above. Corn starch was chosen for comparison because it was the only material available which did not contain protein, of which there is none in the sawdust.

The herd was divided into two groups of three cows each. One group received the "starch" ration for thirty-eight days, while the other group received the "sawdust" ration. At the end of thirty-

eight days the feeds were reversed, those cows that had been getting starch being changed to sawdust and vice versa, for another period of thirty-eight days. Thus each and every cow received both rations. The last twenty-eight days of each period was taken as the basis for calculation of results. The Douglas fir sawdust was fed out first, its trial lasting from October 1, 1924, until December 14, 1924, all cows being in the experiment simultaneously. Because of delays in receipt of the white pine sawdust and also because of irregularity in the freshening dates of the cows available, not all the cows were in this experiment simultaneously. The feeding trial lasted from February 27, 1925, until July 7, 1925.

The ration fed to the cows consisted of: mixed hay and a grain mixture composed of corn meal, 20 per cent; wheat bran, 10 per cent; ground oats, 30 per cent; cottonseed meal, 10 per cent; linseed meal, 15 per cent, and gluten feed, 15 per cent. This mixture contained 16 per cent of digestible protein and constituted about 80 per cent of the daily grain allowance of each cow. The remaining 20 per cent was either starch or an equivalent amount of sawdust. The rations were adjusted in accordance with accepted standards at the beginning of each month, and were calculated a trifle scant in order to have the cows utilize the sawdust as fully as possible.

The amount of sawdust fed was the same in all cases, viz., 4 pounds daily, previous experience having shown that the cows would not readily eat any greater amount. The amount of starch equivalent to this amount of sawdust, taking into consideration the moisture content and relative digestibility of the starch and the two kinds of sawdust, was 1 pound and 4 ounces in the case of the Douglas fir sawdust, and 1 pound and 12 ounces in the case of the white pine sawdust. These were the amounts of starch fed.

The sawdust and starch were well mixed with the other grain before feeding to insure complete consumption. With one exception all the cows throughout both experiments ate their grain-sawdust mixture without waste. The one cow who was at times rather fussy wasted only a few pounds. No digestive disturbances were noted and both experiments were carried to completion satisfactorily.

In summarizing the results attention has been centered on the following points:

1. Milk yield
2. Inital shrinkage in milk flow
3. Change in body weight

MILK YIELD

In the experiment with Douglas fir sawdust versus starch 2 of the cows dried off much more rapidly than we had anticipated, and the same was true of 1 cow in the experiment with white pine sawdust versus starch. For this reason the milk yield records of these individuals have not been included in the reported results. Table 3 gives the comparative yield and quality of the milk in both experiments.

The cows produced 98.5 pounds less milk on the Douglas fir sawdust ration equal to about 4 per cent less solid matter than on the starch ration, and 42 pounds less milk, equivalent to substantially 1 per cent less solid matter on the white pine sawdust ration than on the starch ration. The figures point, therefore, to the fact that, on the basis of digestion equivalents, the hydrolyzed sawdust was rather inferior to the starch, and that the white pine product had a more favorable influence as a nutrient than did the Douglas fir. Differences in the percentage composition of the milk were so slight as to be without significance. The considerably higher percentages of total solids and fat in the Douglas fir experiment are due to the difference in stage of lactation, all the cows being rather advanced in lactation when on this trial, while all but one had recently freshened when put on the white pine sawdust.

INITIAL SHRINKAGE IN MILK FLOW

This was determined by noting the production of each cow during the week immediately preceding the commencement of the experiment and her production during the first week of the experiment proper, there being an interval of ten days between the two periods to allow for any irregularities due to change of feed. Table 4 presents the results.

TABLE 3

Milk production in the sawdust-starch feeding trial

DATE	COWS	MILK	SOLIDS		FAT	
			Experiment I			
			Starch			
1924		*pounds*	*per cent*	*pounds*	*per cent*	*pounds*
October 10 to November 6	Colantha II	1,186.4	12.98	153.99	4.57	54.22
	Colantha IV	609.8	12.16	74.15	3.75	22.87
November 17 to December 14	Samantha IV	569.7	13.73	78.22	4.93	28.09
	Fancy V	475.1	15.32	72.79	5.87	27.89
Total, pounds		2,841.0		379.15		133.07
Average, per cent			13.35		4.68	
			Sawdust (Douglas fir)			
1924						
October 10 to November 6	Samantha IV	691.9	12.87	89.05	4.48	31.00
	Fancy V	504.1	15.23	76.77	5.93	29.89
November 17 to December 14	Colantha II	1,123.0	13.10	147.11	4.46	50.09
	Colantha IV	423.5	12.53	50.62	3.90	16.52
Total, pounds		2,742.5		363.55		127.50
Average, per cent			13.26		4.65	
			Experiment II			
			Starch			
1925						
March 29 to April 25	Diantha	1,616.4	11.46	185.24	3.35	54.15
April 16 to May 13	No. 192	1,005.0	11.59	116.48	3.36	33.74
May 3 to 30	Colantha IV	1,419.0	11.90	168.86	3.62	51.36
May 6 to June 2	Samantha IV	1,238.8	12.24	151.63	4.02	49.80
June 10 to July 7	No. 46	1,046.5	10.96	114.70	3.03	31.71
Total, pounds		6,325.7		736.91		220.76
Average, per cent			11.65		3.49	
			Sawdust (Eastern white pine)			
1925						
March 9 to April 5	No. 192	1,136.0	11.41	129.62	3.27	37.15
March 29 to April 25	Samantha IV	1,310.1	12.24	160.36	3.92	51.36
May 3 to 30	No. 46	1,108.0	11.10	122.99	3.25	36.01
May 6 to June 2	Diantha	1,465.3	11.62	170.27	3.54	51.87
June 10 to July 7	Colantha IV	1,264.3	11.67	147.54	3.47	43.87
Total, pounds		6,283.7		730.78		220.26
Average, per cent			11.63		3.51	

TABLE 4

Showing relative shrinkage in milk yield when cows were put on the experimental ration—starch versus sawdust

COWS	MILK YIELD		INCREASE	DECREASE
	Production during week previous to commencement of experiment	Production during first week of experiment		
		Experiment I		
		Starch		
	pounds	*pounds*	*pounds*	*pounds*
Colantha II	270.7	296.0	25.3	
Colantha IV	183.9	160.8		23.1
Samantha IV	177.0	146.5		30.5
Fancy V	131.9	118.9		13.0
Total	763.5	722.2	25.3	66.6
		Sawdust (Douglas fir)		
Samantha IV	223.8	172.2		51.6
Fancy V	137.7	121.1		16.6
Colantha II	303.9	277.9		26.0
Colantha IV	139.6	106.0		33.6
Total	805.0	677.2		127.8
		Experiment II		
		Starch		
Diantha	436.4	431.2		5.2
No. 192	278.0	260.2		17.8
Colantha IV	353.0	370.9	17.9	
Samantha IV	318.0	316.2		1.8
No. 46	255.7	253.6		2.1
Total	1,641.1	1,632.1	17.9	26.9
		Sawdust (Eastern white pine)		
No. 192	297.5	288.4		9.1
Samantha IV	323.3	337.2	13.9	
No. 46	318.4	295.8		22.6
Diantha	381.5	378.8		2.7
Colantha IV	344.2	321.4		22.8
Total	1,664.9	1,621.6	13.9	57.2

Note: The ten-day preliminary intervenes in each case between the two periods.

With the Douglas fir sawdust versus starch experiment the net decrease was: starch, 41.3 pounds; sawdust, 127.8 pounds. With the white pine sawdust it was starch, 9.0 pounds; sawdust, 43.3 pounds.

After the first month or so of lactation it is normal for a cow to gradually decline in milk production. Any increases reported in the table are due to the fact that the cows in question had not quite reached the peak of their production when the experiment was begun.

CHANGES IN BODY WEIGHT

All cows were weighed on each of three consecutive days at the beginning and end of each half of each experiment. The detailed data are shown in table 5.

TABLE 5

Gain or loss in weight in sawdust-starch experiment

Experiment I (Douglas fir sawdust)

COWS	STARCH				COWS	SAWDUST (DOUGLAS FIR)			
		Weight	Gain	Loss			Weight	Gain	Loss
No. 46	B	1,265			Diantha	B	1,282		
	E	1,310	45			E	1,310	28	
Colantha II	B	1,090			Samantha IV	B	1,272		
	E	1,108	18			E	1,308	36	
Colantha IV	B	1,250			Fancy V	B	892		
	E	1,270	20			E	900	8	
Diantha	B	1,320			No. 46	B	1,320		
	E	1,362	42			E	1,348	28	
Samantha IV	B	1,300			Colantha II	B	1,145		
	E	1,365	65			E	1,133		12
Fancy V	B	915			Colantha IV	B	1,300		
	E	910		5		E	1,298		2
Total			190	5				100	14

Starch—net gain.....185 pounds
Sawdust—net gain..... 86 pounds

TABLE 5—*Continued.*

Experiment II (Eastern white pine sawdust)

COWS	STARCH				COWS	SAWDUST (EASTERN WHITE PINE)			
		Weight	Gain	Loss			Weight	Gain	Loss
Colantha II	B	1,170			No. 192	B	1,255		
	E	1,195	25			E	1,265	10	
Diantha	B	1,265			Samantha IV	B	1,265		
	E	1,285	20			E	1,290	25	
Colantha IV	B	1,245			No. 46	B	1,215		
	E	1,240		5		E	1,190		25
No. 192	B	1,280			Colantha II	B	1,240		
	E	1,325	45			E	1,250	10	
Samantha IV	B	1,275			Diantha	B	1,285		
	E	1,285	10			E	1,280		5
No. 46	B	1,200			Colantha IV	B	1,215		
	E	1,220	20			E	1,245	30	
Total			120	5				75	30

Starch—net gain.....115 pounds
Sawdust—net gain..... 45 pounds

B = beginning of period; E = end of period.

Each weight reported above is an average of three weights taken on consecutive days.

CONCLUSIONS ON THE MILK PRODUCTION INVESTIGATION

The milk yield was slightly higher when starch was fed than when the digestion equivalent of either Douglas fir or white pine sawdust was fed. The white pine made a slightly better showing in this respect than did the Douglas fir.

The initial shrinkage in milk flow was much more marked with both sawdusts than with the starch.

Net gains in body weight were somewhat higher on the starch than on either sawdust although changes in weight were not pronounced.

It is not advisable in an experiment of this kind, with a relatively small number of cows, to draw too definite conclusions.

The results indicate, however, that the animals derived some benefit from the sawdust.

GENERAL CONCLUSIONS

As a result of our studies the following general conclusions are drawn:

1. Hydrolyzed sawdust is composed almost entirely of crude cellulose, lignin, and a mixture of hexose and pentose sugars.

2. Animals will not eat the hydrolyzed sawdust when fed by itself. In order to promote consumption it is necessary to mix it with other grains. Occasionally an animal will refuse to eat the mixture of which the sawdust is a component.

3. About 4 pounds daily is all that the mature dairy cow will consume, especially, if it is fed for any length of time.

4. Digestion studies show that the dry matter of the Eastern white pine sawdust was about 46 per cent digestible, while that of the Douglas fir sawdust was about 33 per cent digestible. In the case of the Douglas fir sawdust, digestion was confined principally to the invert sugar formed by the hydrolysis, while in the case of the white pine sawdust apparently some of the cellulose was digested also. The "residue" from the white pine sawdust is substantially worthless as a feed, and presumably the same is true of that from Douglas fir. Although no digestion studies were made on the latter the inference is that the total product from the Douglas fir having proved inferior to that from the white pine, the same would be true of the "residue."

5. If the process of hydrolysis could be modified so as to convert a larger proportion of the cellulose of the wood into sugar, or more completely separate the cellulose from the lignin the food value of the material would be enhanced. If the above is not possible from the standpoint of economy it might be worth while to mix the extract with a carrier having some substantial food value. The mixing of the extract with the inert residue produces an inferior food product.

6. The evidence at hand indicates that the white pine sawdust is likely to respond to treatment better than the Douglas fir.

This may be due to the fact that in the white pine the linkage between lignin and cellulose is less firm than it is in the Douglas fir.

7. On the basis of equal amounts of digestible nutrients the sawdust when fed to dairy cows produced only slightly smaller amounts of milk than did corn starch, but it took, on an average, 2.75 pounds of sawdust to equal one pound of starch.

8. On the basis of the present supply and cost of carbohydrate concentrates it is not believed that the product as now prepared has any economic value. Under unusual conditions, as in case of an extreme shortage of ordinary feedstuffs, it might be used as a partial substitute for the cereal grains or starchy by-products.

9. The Forest Service of the United States Department of Agriculture is to be commended for its efforts to find a use for the vast amounts of waste sawdust. Progress has been made and it is hoped that a continuance of the study will bring us nearer a satisfactory solution of the problem.

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PEROXIDASE AS A FACTOR IN BUTTER DETERIORATION*

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The extent to which the natural enzymes of milk contribute to the deterioration of butter is still an unsettled question. This is especially true for peroxidase, which is certainly the most abundant as well as the most potent of the oxidizing ferments normal to milk.

When cream is pasteurized at temperatures sufficiently high to destroy peroxidase, the keeping quality of the butter is often enhanced. Rogers, Berg, and Davis (1) Rogers, Berg, Potteiger, and Davis (2), Larson, Fuller, Jones, Gregory, and Tolstrup (3), and Hunziker, Spitzer, Mills and Switzer (4) have obtained results of this character, although Mortensen, Gaessler, and Cooper (5) were unable to detect such an effect. The data of Palmer and Combs (6) on tallowy decomposition of butter can also be interpreted as showing that the natural oxidases are a factor, at least in this type of deterioration.

Regardless of whether there are sufficient data to show definitely that the temperature of pasteurization is a major factor in determining the keeping quality of butter, it must be admitted that there has been a tacit assumption among buttermakers that the destruction of all enzymes in cream is an important aid in butter storage. So far as peroxidase is concerned the widespread use of the Storch test in creamery practice has given rise to the belief that peroxidase itself is detrimental to the keeping quality of butter.

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A more direct means of determining the effect of peroxidase in butter deterioration suggested itself to us, namely, to add large quantities of the enzyme to cream which had been rendered free of enzymes by heat and to observe the keeping quality of the butter in comparison with check lots containing no peroxidase. The present paper sets forth briefly the results of such an experiment.

EXPERIMENTAL

Method of procedure

Peroxidase was concentrated from horse-radish roots according to the method of Willstätter and Stoll (7) as modified by Willstätter (8). The aqueous solution of nearly pure peroxidase obtained from 10 kgm. of roots was concentrated under reduced pressure. This solution had a yellow color and spicy flavor. A qualitative examination showed that purpurogallin was readily produced in large quantities from pyrogallol when the enzyme solution was tested by a method essentially like that recommended by Rice and Hanzawa (9).

The effect of the enzyme was determined in both sweet and ripened cream butter at room temperature and at 0°C. A 40-pound lot of 40 per cent cream was pasteurized at 180°F. for ten-minutes and then divided into four equal parts. Two of these were ripened with starter to an acidity of 0.6 per cent. One hundred ten cubic centimeters of peroxidase solution were added to one 10 pound lot of both sweet and ripened cream, the other two portions being kept as checks. All four lots were then churned and the butter drained, washed, salted, and worked in the usual manner. The butter from each lot was packed in one-pint glass jars having glass tops, rubber seals, and metal clamps. Aseptic conditions were maintained as far as possible throughout, all utensils, jars, etc., being sterilized in flowing steam. One-half of each lot of butter was stored at room temperature and the other half at 0°C. The average composition of the butter from 24 one-pint samples, including six from each lot, as determined by the Kohman method was as follows: fat, 82.5 per cent; moisture, 13.9 per cent; salt, 2.9 per cent; and curd, 0.7 per cent.

Examination of the various lots and sub-lots of butter was made at intervals of approximately 115, 180, and 335 days from the date of churning. The examination included (*a*) a study of the organic and amino acids in the aqueous phase of the butter, (*b*) peroxidase tests on the aqueous phase of the butter, (*c*) the Kreis test on the butter fat and (*d*) a determination of the amount of oxidized fatty acids in the fat. In addition there was a general examination for quality of the stored samples.

The organic and amino acids in the butter serum were determined by the Foreman (10) method, the serum being isolated from 200 grams of butter by a modification of the method suggested by Hunziker and others (4), the serum and washings being made up to 500 cc. volume. The presence of peroxidase was detected with the guaiac, paraphenylenediamine (Storch) and pyrogallol reagents. The Kreis test was made by Kerr's (11) modification and the amount of oxidized (petroleum-ether insoluble) fatty acids determined by Fahrion's (12) method.

Results

The effects of the added peroxidase were entirely negative throughout so far as any chemical changes or evidences of deterioration due to the presence of excessive amounts of peroxidase were concerned, making it unnecessary to give analytical results in detail. There was no proteolysis whatever in either the enzyme or check samples, even after eleven months at room temperature. It was not expected that peroxidase would be a factor in deterioration of this type; the result, however, serves to show that the butter was entirely free from other important agents of deterioration. All enzyme samples gave strong tests for peroxidase throughout the entire period of observation showing that active enzyme was present at all times. The Kreis test was negative for all samples, even those stored for nearly a year at room temperature. Petroleum-ether insoluble fatty acids were determined only at the end of the three months storage period. The amount ranged from 0.3 to 0.9 gram per 100 grams of butter fat, but there were no differences between the enzyme and check samples that could be determined by this method.

The general quality of all the samples of butter was good. There was no difference between the enzyme and check samples as to odor, flavor or color. There was no bleaching in any case. All the samples stored at 0°C. were edible and were pronounced good butter, even after eleven months storage. The samples held at room temperature for the same period were also remarkably well preserved considering their age and method of storage. All persons to whom they were shown exhibited great surprise at their quality. The only pronounced defects in the cold storage and room temperature samples was a mealy quality in the former and a stale flavor in the latter.

CONCLUSIONS

Peroxidase in itself is not a factor in the deterioration of storage butter. The enhanced keeping quality observed in butter made from cream pasteurized at high temperatures is due to the elimination of agents for deterioration other than the peroxidase enzyme.

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A BABCOCK-GERBER METHOD FOR DETERMINING THE PERCENTAGE OF FAT IN ICE CREAM*

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A fat standard for ice cream has been set by the Federal Government and by practically every state in the Union which makes a very eminent demand for a quick, inexpensive and fairly accurate method for determining the percentage of fat in ice cream. In the last few years there has been submitted to the dairy industry, numerous methods for determining the percentage of fat in the ice cream. The most recent of these methods is the Troy-Fucoma method which is a modification of the Gerber method of testing dairy products as used in Europe. Where careful analytical results are desired the Mojonnier method is to be recommended but this method takes time and is rather expensive when the cost of equipment is considered. Due to the cost of the Mojonnier test it is impracticable and impossible for the small ice cream manufacturer to use this method. Experiments with the Troy-Fucoma method have shown that this method checks closer with the Mojonnier than any of the other methods which are now in use for testing ice cream for butterfat. The belief that the reagents used in the Troy-Fucoma test would work in the Babcock test bottle and thus eliminate the necessity of buying additional testing equipment, led to this experiment.

PLAN OF EXPERIMENT AND EXPERIMENTAL METHODS

Forty samples of ice cream were tested by each of the three methods. These samples of ice cream were secured from the retail stores in New Brunswick and represent samples from six different manufacturers, a pint of ice cream being purchased for each sample. The samples were melted in a water bath and

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brought to about room temperature. As soon as the samples had reached this temperature they were thoroughly mixed and charges weighed out for each of the three methods studied.

A. Babcock-Gerber method. Since amyl alcohol is slightly soluble in butterfat in the preliminary trials with this method the alcohol was used in the following amounts: 1.5, 1.8, and 2 cc. It was found that 1.5 cc. of amyl alcohol did not give as clear and as well defined fat columns or did the results check as close with the Mojonnier as when 1.8 or 2 cc. were used. In the Troy-Fucoma method they use 1 cc. of amyl alcohol per 5 grams of ice cream which is equivalent to using 1.8 cc. of alcohol per 9 grams of ice cream in the Babcock-Gerber method. In a few cases slightly higher results were secured by using 2 cc. of amyl alcohol. However, these results were well within the experimental error and for actual practice the solubility of the amyl alcohol in butterfat is not great enough to be a factor in the test when only enough is used to secure a clear fat column. Both the 9-gram 20 per cent ice cream bottles and the 9-gram 50 per cent cream bottles were used in this experiment. Since the 9-gram 20 per cent ice cream bottles are graduated in 0.2 per cent they should be used with this method. The samples were centrifuged in an electric non-heated tester. The directions for making the test are as follows:

1. Weigh exactly 9 grams of well mixed sample into 9 gram 20 per cent ice cream test bottle.
2. Add 9 cc. of water and 1.8 cc. of amyl alcohol.
3. Mix thoroughly.
4. Add 17.5 cc. of diluted commercial sulphuric acid (94 cc. of acid to 6 cc. of water for chocolate ice cream or 87 cc. of acid to 13 cc. of water for other flavors) in three proportions and mix thoroughly after each addition of acid and finally give samples a vigorous shaking. (To obtain a clear fat column this is very important.)
5. Centrifuge for five minutes.
6. Add hot water to bring contents up to the bottom of the neck of the bottle.
7. Centrifuge for two minutes.
8. Add hot water to bring the bottom of the fat column well within the neck of the bottle.
9. Centrifuge for one minute.

10. Place bottles in a hot water bath at a temperature of 135° to 140°F. and leave for five minutes.

11. Remove each bottle as it is to be read, add red reader and read per cent of fat with dividers.

B. Gerber or Troy-Fucoma method. Much difficulty was experienced with the Troy-Fucoma test in the preliminary trials and considerable time was spent in determining what method of procedure gave the best results. Troy's method as published by the Fucoma Company was first used and the results were very unsatisfactory both from standpoint of clearness of fat column and comparison to Mojonnier. The following method which is a slight modification of the one recommended by Fisher and Walts (1) was found to give the best results.

1. Measure 10 cc. of diluted commercial sulphuric acid (94 cc. of acid to 6 cc. of water for chocolate ice cream or 87 cc. of acid to 13 cc. of water for other flavors) into special ice cream test bottles.

2. Weigh exactly 5 grams of well mixed sample into test bottle using care to let the ice cream run down the side of the test bottle and spread over the surface of the acid without mixing it.

3. Add 5.5 to 6 cc. of water (depending on size of bottle) and 1 cc. of amyl alcohol; insert rubber stopper and mix contents by inverting test bottles until contents are thoroughly mixed.

4. Centrifuge immediately at a speed of 1000 to 1200 revolutions per minute for about four minutes.

5. Place in water bath at 135° and hold for about five minutes.

6. Centrifuge for two minutes.

7. As soon as centrifuging is complete place in water bath at 135°F. for five minutes and read with dividers.

C. Mojonnier method. The directions for testing ice cream for fat and total solids by the Mojonnier method as outlined by Mojonnier and Troy (11) were followed exactly.

RESULTS

The percentage of fat obtained on the forty samples by each of the three methods used and the total solid content are tabulated in tables 1, 2 and 3. Table 1 consists of eighteen samples of

vanilla, table 2 consists of twelve samples of chocolate and table 3 consists of ten samples of strawberry. Taking the Mojonnier or modified Roese-Gottleib method as the standard for comparison, the per cent of variation of each of the Troy-Fucoma and the Babcock-Gerber from the Mojonnier are reported in tables 1 to 3.

TABLE 1

Percentages of fat in vanilla ice cream as determined by Mojonnier, the Troy-Fucoma and Babcock-Gerber method

SAMPLE NUMBER	MOJONNIER		TROY-FUCOMA		BABCOCK-GERBER				PER CENT VARIATION		
	Fat	Total solids	Original	Duplicate	9 gram 20 per cent bottle		9 gram 50 per cent bottle		Troy-Fucoma from Mojonnier	Babcock-Gerber from Mojonnier	
					Original	Duplicate	Original	Duplicate		20 per cent bottle	50 per cent bottle
1	10.71	38.29	10.6	10.5	10.6	10.4	11.0	11.0	−0.16	−0.21	+0.29
2	11.19	39.86	10.8	11.0	11.4	11.4	11.5	11.5	−0.29	+0.21	+0.31
3	10.68	36.43	10.8	10.8	10.8	10.8	11.0	11.0	+0.12	+0.12	+0.32
4	11.65	37.78	11.2	11.6	11.8	11.8	12.0	12.0	−0.25	+0.15	+0.35
5	11.63	37.67	12.0	11.6	11.8	11.8	12.0	11.5	+0.17	+0.17	+0.12
6	14.64	40.35	13.8	13.8	14.5	14.4	14.5	15.0	−0.84	−0.19	−0.64
7	14.14	39.03	13.2	13.2	13.8	13.6	13.5	13.5	−0.84	−0.44	−0.64
8	14.59	40.52	14.4	14.6	14.8	14.6	15.0	15.0	−0.09	+0.11	+0.41
9	12.90	38.42	12.6	12.4	12.8	12.6	12.5	12.5	−0.40	−0.20	−0.40
10	14.05	38.67	13.6	13 4	14.2	14.2	14.0	14.0	−0.55	+0.15	−0.05
11	11.37	38.73	10.6	10.8	11.4	11.4	11.5	11.5	−0.61	−0.41	−0.31
12	12.92	37.85	12.6	12.8	12.8	12.8	13.0	13.0	−0.22	−0.12	+0.08
13	10.84	37.65	10.4	10.6	11.0	11.0	11.0	11.0	−0.34	+0.16	+0.16
14	11.56	39.09	12.6	12.6	11.6	11.4	11.5	12.0	+0.94	−0.06	+0.19
15	11.87	38.28	11.6	11.6	11.8	11.8	12.0	12.0	−0.27	−0.07	+0.13
16	11.07	38.53	10.6	10.4	11.0	11.2	11.0	11.0	−0.57	+0.03	−0.07
17	11.48	39.47	10.4	10.6	11.8	11.6	12.0	12.0	−1.02	+0.22	+0.52
18	11.04	38.23	11.2	11.4	11.2	11.2	11.0	11.0	+0.26	+0.16	−0.04
Average variation									0.44	0.17	0.25

The average variation from the Mojonnier on eighteen samples of vanilla ice cream was 0.44 per cent, in case of the Troy-Fucoma; 0.17 per cent, for the Babcock-Gerber method using the 9-gram 20 per cent ice cream bottles and 0.25 per cent using the 9-gram 50 per cent cream bottles. The results obtained with the chocolate samples were higher with both the Troy-Fucoma and Babcock-Gerber with the exception of the Babcock-Gerber when

TABLE 2

Percentage of fat in chocolate ice cream as determined by Mojonnier, the Troy-Fucoma and Babcock-Gerber method

SAMPLE NUMBER	MOJONNIER		TROY-FUCOMA		BABCOCK-GERBER				PER CENT VARIATION		
					9 gram 20 per cent bottle		9 gram 50 per cent bottle			Babcock-Gerber from Mojonnier	
	Fat	Total solids	Original	Duplicate	Original	Duplicate	Original	Duplicate	Troy-Fucoma from Mojonnier	20 per cent bottle	50 per cent bottle
1	12.16	41.91	11.8	11.7	12.4	12.3	12.5	12.5	−0.41	+0.19	+0.34
2	10.99	38.81	11.0	10.7	11.0	11.0	11.0	11.0	−0.14	+0.01	+0.01
3	16.44	44.40	16.0	16.2	16.4	16.5	16.5	16.5	−0.34	+0.01	+0.06
4	15.53	43.38	14.6	15.0	15.4	15.5	15.5	15.5	−0.73	−0.08	−0.03
5	14.18	41.57	13.6	13.2	13.6	13.6	13.5	13.5	−0.78	−0.58	−0.68
6	15.00	40.64	14.0	14.0	14.4	14.6	14.5	14.5	−1.00	−0.50	−0.50
7	11.72	40.26	11.4	11.2	11.8	11.8	12.0	12.0	−0.42	+0.08	+0.28
8	11.81	40.18	11.2	11.2	11.4	11.4	11.5	11.5	−0.36	+0.04	+0.24
9	10.70	39.82	9.6	9.8	10.2	10.2	10.5	10.5	−1.00	−0.70	−0.20
10	11.53	39.86	11.4	11.4	11.6	11.6	11.5	11.5	−0.13	+0.07	−0.03
11	10.86	40.45	10.4	10.4	10.4	10.4	10.5	10.5	−0.46	−0.46	−0.36
12	11.36	41.04	11.0	11.2	11.6	11.4	11.5	11.5	−0.25	+0.15	+0.15
Average variation									0.51	0.24	0.24

TABLE 3

Percentage of fat in strawberry ice cream as determined by Mojonnier, the Troy-Fucoma and Babcock-Gerber method

SAMPLE NUMBER	MOJONNIER		TROY-FUCOMA		BABCOCK-GERBER				PER CENT VARIATION		
					9 gram 20 per cent bottle		9 gram 50 per cent bottle			Babcock-Gerber from Mojonnier	
	Fat	Total solids	Original	Duplicate	Original	Duplicate	Original	Duplicate	Troy-Fucoma from Mojonnier	20 per cent bottle	50 per cent bottle
1	9.61	39.67	9.8	9.8	9.8	9.8	10.0	10.0	−0.19	+0.19	+0.39
2	13.79	40.62	13.8	14.0	14.0	14.0	14.0	14.0	+0.11	+0.21	+0.21
3	12.36	40.68	11.8	12.0	12.2	12.2	12.0	12.0	−1.15	−0.16	−0.36
4	12.97	38.47	13.0	13.0	13.0	13.0	13.0	13.0	−0.03	−0.03	−0.03
5	9.51	37.65	9.4	9.6	9.6	9.4	9.5	9.5	+0.01	+0.01	+0.01
6	10.26	38.10	10.0	9.8	10.2	10.4	10.5	10.5	−0.36	+0.04	+0.24
7	10.51	34.73	9.8	9.8	10.2	10.2	10.5	10.5	−0.71	−0.31	−0.01
8	9.63	37.20	10.0	9.8	10.0	9.8	10.0	10.0	−0.27	−0.27	−0.37
9	9.72	37.75	9.8	10.0	10.0	10.0	10.0	10.0	+0.18	+0.28	+0.28
10	9.44	38.23	8.6	8.8	9.4	9.4	9.5	9.5	−0.74	−0.04	+0.06
Average variation									0.37	0.15	0.19

the 9-gram 50 per cent test bottles were used. The average variation from the Mojonnier in the case of the twelve chocolate samples was 0.51 per cent for Troy-Fucoma and 0.24 per cent for Babcock-Gerber for both kinds of test bottles. The reason for these higher results is likely due to the fact that chocolate ice cream is generally believed to be much harder to test by any method than the other flavors because of the rich fat content in the chocolate itself, and that the acid does not completely dissolve the solids not fat. The strawberry ice cream checked closer with the Mojonnier by both methods than did either of the other two flavors. The reason for this may be that on the average the fat and total solids content of the strawberry ice cream was lower than the other two flavors. The difference, when compared to the chocolate samples, amounts to about 2 per cent for fat and 2.7 per cent for total solids. The average variation from the Mojonnier on ten samples of strawberry ice cream was 0.37 per cent in case of Troy-Fucoma; 0.15 per cent for the Babcock-Gerber using the 9-gram 20 per cent ice cream bottles and 0.19 per cent using the 9–gram 50 per cent cream bottles.

Considering the three flavors as one group the average variation from the Mojonnier on the forty samples was 0.44 per cent in case of Troy-Fucoma, 0.19 per cent for the Babcock-Gerber using the 9-gram 20 per cent ice cream bottles and 0.23 per cent using the 9-gram 50 per cent cream bottles. The average variation for the Troy-Fucoma method is slightly higher than that found by Fisher and Walts (3) and the variation for the Babcock-Gerber method is much less than the one they reported for their Modified Babcock method using ethyl alcohol and sulphuric acid.

In order to determine the accuracy of the Troy-Fucoma and Babcock-Gerber methods when the Mojonnier is used as a standard for comparison, the results of the forty samples have been summarized in table 4.

A study of this table shows more favorable results for the Babcock-Gerber method. In the case of this method 67.5 per cent of all samples checked within 0.2 per cent (smallest graduation on bottle), while with the Troy-Fucoma method only 25

per cent of samples checked within 0.2 per cent of the Mojonnier. If a comparison is made with the Babcock-Gerber method using the 9-gram 50 per cent cream bottles, twice as many samples checked within 0.2 per cent of Mojonnier as in case of Troy-Fucoma and 92.5 per cent checked within 0.5 per cent (smallest graduation on bottle). Also only 38 samples or 95 per cent of

TABLE 4

Summary of percentages of variation of Troy-Fucoma from Mojonnier method

3 samples or	7.5 per cent checked within 0.1	of 1 per cent of Mojonnier
10 samples or	25.0 per cent checked within 0.2	of 1 per cent of Mojonnier
18 samples or	45.0 per cent checked within 0.3	of 1 per cent of Mojonnier
22 samples or	55.0 per cent checked within 0.4	of 1 per cent of Mojonnier
25 samples or	62.5 per cent checked within 0.5	of 1 per cent of Mojonnier
32 samples or	80.0 per cent checked within 0.75	of 1 per cent of Mojonnier
38 samples or	95.0 per cent checked within 1.00	of 1 per cent of Mojonnier

Summary of percentages of variation of Babcock-Gerber from Mojonnier method using 9 gram 20 per cent ice cream bottle

13 samples or	32.5 per cent checked within 0.1	of 1 per cent of Mojonnier
27 samples or	67.5 per cent checked within 0.2	of 1 per cent of Mojonnier
33 samples or	82.5 per cent checked within 0.3	of 1 per cent of Mojonnier
34 samples or	85.0 per cent checked within 0.4	of 1 per cent of Mojonnier
38 samples or	95.0 per cent checked within 0.5	of 1 per cent of Mojonnier
40 samples or	100.0 per cent checked within 0.75	of 1 per cent of Mojonnier

Summary of percentages of variation of Babcock-Gerber from Mojonnier method using 9 gram 50 per cent cream bottle

12 samples or	30.0 per cent checked within 0.1	of 1 per cent of Mojonnier
20 samples or	50.0 per cent checked within 0.2	of 1 per cent of Mojonnier
24 samples or	60.0 per cent checked within 0.3	of 1 per cent of Mojonnier
34 samples or	85.0 per cent checked within 0.4	of 1 per cent of Mojonnier
37 samples or	92.5 per cent checked within 0.5	of 1 per cent of Mojonnier
40 samples or	100.0 per cent checked within 0.75	of 1 per cent of Mojonnier

all samples checked within 1.00 per cent from Mojonnier in case of Troy-Fucoma and all the samples checked within 0.75 per cent in the case of Babcock-Gerber.

A comparison was made as to whether these methods gave results which were higher or lower than the Mojonnier and the study showed 32 out of the 40 samples gave results somewhat lower than the Mojonnier in case of Troy-Fucoma method, while

only 18 samples were lower with the Babcock-Gerber method for the 9-gram 20 per cent ice cream bottles and 17 samples for the 9-gram 50 per cent cream bottles.

Much difficulty was experienced with the Troy-Fucoma method in securing a clear fat column and also duplicate checks. If the method used was such that the fat column consisted of about half fat and the other half a hazy film the results seemed to check closer but the difficulty with this is to secure the right amount of hazy film. Also by screwing the rubber stopper at the bottom of the bottle some of the materials are forced up into the fat column thus increasing the reading. In this experiment duplicate determinations were repeated until a clear fat column was

TABLE 5

Effect of total solids on percentages of variations of Troy-Fucoma and Babcock-Gerber methods from Mojonnier method

	TROY-FUCOMA	BABCOCK-GERBER	
		20 per cent bottles	50 per cent bottles
Average variation of all 40 samples	0.44	0.19	0.23
Average variation of all 20 samples with highest solid content	0.58	0.23	0.30
Average variation of 20 samples with lowest solid content	0.32	0.14	0.16

obtained and in some cases with chocolate ice cream this required as many as six trials. In the case of one sample of chocolate ice cream not reported in this experiment a total of seven trials was made and on only one bottle was a fat reading of 10.6 per cent secured and the reading on duplicate bottle was less than 9 per cent. The Mojonnier on this sample was 12.05 per cent and the Babcock-Gerber 11.85 for the 9-gram 20 per cent ice cream bottles and 12 per cent for the 9-gram 50 per cent cream bottles. In no case was more than one determination required on any one sample with the Babcock-Gerber method.

A study of accuracy of the Troy-Fucoma and Babcock-Gerber methods as effected by the total solids in the ice cream are reported in table 5.

From this table it will be noted that the 20 samples with lowest solid content checked closer by both methods. All samples in the second group have a solid content above 39 per cent. Since these figures show a wide variation, similar experiments should be conducted at other laboratories, before any definite conclusions should be drawn.

SUMMARY AND CONCLUSIONS

1. The Babcock-Gerber method for determining the percentage of fat in ice cream is the adaption of the reagents in the Troy-Fucoma method applied to Babcock equipment.

2. To study the relative value of the Babcock-Gerber method as compared to the Troy-Fucoma and Mojonnier method, 40 samples of ice cream were analyzed by these three methods.

3. Much difficulty was experienced in obtaining clear fat columns and duplicate checks with the Troy-Fucoma method.

4. Using the Mojonnier method as a standard for comparison the results indicate that the Babcock-Gerber method is 231 per cent more accurate than the Troy-Fucoma.

5. The average per cent of variation from the Mojonnier on 40 samples was 0.44 per cent for Troy-Fucoma, 0.19 per cent for Babcock-Gerber using the 9-gram 20 per cent ice cream bottles and 0.23 per cent using the 9-gram 50 per cent cream bottles.

6. The Babcock-Gerber method seems well adapted for factory use where simplicity, cost of equipment and time are important considerations, however, where accurate analytical results are desired the Mojonnier should be used.

7. With the Babcock-Gerber method 67.5 per cent of all samples checked within 0.2 per cent while with the Troy-Fucoma method only 25 per cent of the samples checked within 0.2 per cent of the Mojonnier.

8. It would seem that the higher the total solids content, the more difficult it is to obtain accurate results when sulphuric acid is used as the solvent.

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OFFICIAL RECORDS AS MATERIAL FOR STUDYING INHERITANCE OF MILK AND BUTTERFAT PRODUCTION*

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During the past two decades a large number of purebred cows of the dairy breeds have been officially tested for milk and butterfat production. These tests have been carefully supervised by the agricultural colleges of the country, and the accuracy and thoroughness of this work is safeguarded by carefully drawn and rigidly enforced rules. The results of these tests as published by the breed associations in the various volumes of the Advanced Register and Register of Merit make up a vast reservoir of material of recognized value for the statistician.

For the purpose of assaying these records as material for studying the inheritance of milk and butterfat production, the initial and reëntry records of all cows of three breeds having two or more records have been arranged in age groups. This method of study was used in order to determine the correlation existing between records made at two different ages by the same group of cows. The correlations are based on actual initial and reëntry records made at corresponding ages by each cow in the groups.

It is assumed that any official record of production is a demonstration of the inherited ability of the cow to produce milk and butterfat, and the extent to which this ability is hindered by the combination of things constituting environment. The term environment is used in its broad sense, and includes all factors other than genetic or heritable factors, such as methods of feeding, climate, housing, number of daily milkings, season of freshening, disease, accidents, etc. If we assume that the environment is such as to afford the inherited ability full and unrestricted play; then it would appear that the correlation between the initial and

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reëntry records made by a group of cows at corresponding ages should be perfect. In other words, the relative ranking of the records of a group of cows on reëntry should be the same as the relative ranking of the initial records made by the same group of cows at an earlier age. The variation of this correlation from plus one should measure the extent to which environment interferes with the complete expression of the inherited ability, and should indicate the value of such records for studying heredity.

Nineteen groups of Guernsey cows were studied, and the data on their initial and reëntry butterfat records are listed in table 1. The coefficients of correlation vary from 0.8591 ± 0.0442 to 0.3290 ± 0.1228. Six other correlation coefficients are above 0.7, six above 0.6, four above 0.5, while only two fall below 0.5. The average correlation coefficient is 0.6605. The requirements for entry in the Advanced Register increase from two years up to five years of age, and the higher requirement at the reëntry age automatically excluded a certain proportion of records which might have been lower than the initial records made by the same individuals. Of the 674 animals in this study, 593 could have qualified for reëntry at the ages shown, even though they had produced less fat on the retest. Of these 593 animals, 43, or 7.25 per cent, made less fat on reëntry test than on initial test.

Data on 33 groups of Jerseys with initial and reëntry butterfat records are shown in table 2. The correlation coefficients vary from 0.8116 ± 0.0482 to 0.3391 ± 0.1107, with an average of 0.6071. Six others are over 0.7 and nine over 0.6. Seven are over 0.5, six over 0.4, and four over 0.3. Twenty-three are above 0.5 and ten below. Four hundred seventy-five of the 2419 cows would have been excluded from reëntry by the requirements if the reëntry record had been less than the initial record. Of the other 1944 animals, 293, or 15 per cent, produced less on retest than on the initial test.

Sixteen groups of Ayrshire cows with initial and reëntry milk records were studied, and the data are listed in table 3. The highest coefficient of correlation is 0.6445 ± 0.0861, and the lowest is 0.0826 ± 0.0391. The average coefficient of correlation is 0.5021. Three others are over 0.6, five are over 0.5, two are above

TABLE 1

Correlation coefficients of initial and reentry records made by Guernsey cows at various ages

NUMBER OF COWS	INITIAL RECORD AGE	REENTRY RECORD AGE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	COEFFICIENT OF CORRELATION
	years	years	pounds	pounds		
46	2 to 2½		424±8	76±5	18.4±1.3	+0.7390±0.0452
		3 to 3½	501±10	100±7	20.0±1.4	
106	2 to 2½		448±6	90±4	20.1±0.9	+0.7247±0.0311
		3½ to 4	551±8	122±6	22.1±1.0	
50	2 to 2½		427±9	92±6	21.5±1.5	+0.6953±0.0494
		4 to 4½	541±12	121±8	22.4±1.5	
70	2 to 2½		435±6	77±4	17.7±1.0	+0.6059±0.0510
		4½ to 5	552±9	106±6	19.2±1.1	
36	2 to 2½		418±12	103±8	24.6±2.0	+0.6549±0.0642
		5 to 5½	596±17	152±12	25.5±2.0	
34	2 to 2½		416±10	87±7	20.9±1.7	+0.7152±0.0565
		5½ to 6	574±13	115±9	20.0±1.6	
34	2 to 2½		430±9	81±7	18.8±1.5	+0.6553±0.0660
		6 to 6½	600±14	119±10	19.8±1.6	
43	2½ to 3		448±8	77±6	17.2±1.3	+0.5766±0.0686
		3½ to 4	529±9	85±6	16.1±1.2	
47	2½ to 3		447±9	96±7	21.4±1.5	+0.7936±0.0364
		4 to 4½	544±13	137±10	25.2±1.8	
27	2½ to 3		434±9	73±7	16.8±1.5	+0.5080±0.0962
		4½ to 5	547±14	108±10	19.7±1.8	
23	2½ to 3		455±10	70±7	15.4±1.5	+0.5331±0.1005
		5 to 5½	558±16	117±12	21.0±2.1	
20	3 to 3½		421±11	74±8	17.6±1.9	+0.4955±0.1138
		4 to 4½	550±14	94±10	17.1±1.8	
30	3 to 3½		442±11	88±8	19.9±1.7	+0.6506±0.0710
		4½ to 5	567±10	83±7	14.6±1.3	
18	3 to 3½		422±11	70±8	16.6±1.9	+0.7501±0.0696
		5 to 5½	574±14	89±10	15.5±1.7	
24	3 to 3½		459±11	82±8	17.9±1.7	+0.3290±0.1228
		5½ to 6	565±11	77±7	13.6±1.3	
17	3½ to 4		479±15	89±10	18.6±2.2	+0.5959±0.1056
		4½ to 5	556±17	103±12	18.5±2.1	
19	3½ to 4		443±14	91±10	20.5±2.2	+0.6945±0.0801
		5 to 5½	546±18	117±13	21.4±2.3	
14	4 to 4½		506±19	103±13	20.4±2.6	+0.7872±0.0686
		5½ to 6	580±21	119±15	20.5±2.6	
16	4 to 4½		464±13	76±9	16.4±2.0	+0.8591±0.0442
		6½ to 7	566±20	117±14	20.7±2.5	

Average coefficient of correlation, 0.6605.

TABLE 2

Correlation coefficients of initial and reentry butterfat records made by Jersey cows at various ages

NUMBER OF COWS	INITIAL RECORD AGE	REENTRY RECORD AGE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	COEFFICIENT OF CORRELATION
	years	*years*	*pounds*	*pounds*		
51	1½ to 2		340±6	60±4	17.6±1.2	+0.6597±0.0533
		2½ to 3	412±8	87±6	21.1±1.4	
127	1½ to 2		357±5	76±3	21.3±0.9	+0.7057±0.0300
		3 to 3½	452±6	100±4	22.1±0.9	
40	1½ to 2		342±7	64±5	18.7±1.4	+0.6221±0.0654
		3½ to 4	480±10	91±7	12.8±1.0	
71	1½ to 2		343±6	71±4	20.7±1.2	+0.4845±0.0612
		4 to 4½	508±8	106±6	20.9±1.2	
240	2 to 2½		384±4	83±3	21.6±0.7	+0.6318±0.0262
		3 to 3½	477±5	116±4	24.3±0.7	
218	2 to 2½		395±4	86±3	21.8±0.7	+0.6940±0.0237
		3½ to 4	494±5	118±4	23.9±0.8	
168	2 to 2½		367±4	68±3	18.5±0.7	+0.5877±0.0341
		4 to 4½	496±6	107±4	21.6±0.8	
152	2 to 2½		391±5	83±3	21.2±0.8	+0.5754±0.0366
		4½ to 5	553±7	124±5	22.4±0.9	
105	2 to 2½		388±6	88±4	22.7±1.0	+0.5478±0.0326
		5 to 5½	535±8	115±5	21.5±1.0	
90	2 to 2½		375±5	77±4	20.5±1.0	+0.5818±0.0470
		5½ to 6	563±10	145±7	25.8±1.3	
116	2½ to 3		395±5	77±3	19.5±0.8	+0.7736±0.0252
		3½ to 4	485±6	96±4	19.7±0.9	
99	2½ to 3		404±6	88±4	21.8±1.0	+0.7105±0.0336
		4 to 4½	523±9	128±6	24.5±1.2	
53	2½ to 3		407±9	96±6	23.6±1.5	+0.6103±0.0581
		4½ to 5	514±11	116±8	22.6±1.5	
60	2½ to 3		399±6	72±4	18.0±1.1	+0.3707±0.0751
		5 to 5½	535±11	123±8	23.0±1.4	
84	3 to 3½		420±6	87±7	20.7±1.1	+0.7190±0.0355
		4 to 4½	503±8	115±6	22.9±1.2	
68	3 to 3½		434±7	86±5	19.8±1.1	+0.6138±0.0509
		4½ to 5	516±9	109±6	21.1±1.2	
56	3 to 3½		419±8	92±6	22.1±1.4	+0.6701±0.0497
		5 to 5½	525±8	88±6	16.8±1.1	
53	3 to 3½		420±8	88±6	21.0±1.4	+0.5881±0.0606
		5½ to 6	518±10	109±7	21.0±1.4	
61	3½ to 4		423±7	82±5	19.4±1.2	+0.4626±0.0679
		4½ to 5	514±9	109±7	21.2±1.3	
57	3½ to 4		446±8	85±5	19.1±1.2	+0.6668±0.0496
		5 to 5½	532±9	102±6	19.2±1.2	
41	3½ to 4		416±8	79±6	19.0±1.4	+0.3886±0.0895
		6 to 6½	495±10	99±7	20.0±1.5	

TABLE 2—*Continued*

NUMBER OF COWS	INITIAL RECORD AGE	REENTRY RECORD AGE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	COEFFICIENT OF CORRELATION
	years	*years*	*pounds*	*pounds*		
66	4 to 4½		436±7	81±5	18.6±1.1	+0.4767±0.0642
		5 to 5½	488±8	95±6	19.5±1.1	
53	4 to 4½		454±7	74±5	16.3±1.1	+0.4070±0.0773
		5½ to 6	540±9	96±6	17.8±1.2	
39	4½ to 5		449±8	74±6	16.5±1.3	+0.4997±0.0810
		5½ to 6	513±11	103±8	20.1±1.5	
29	4½ to 5		479±12	97±9	20.3±1.8	+0.3391±0.1107
		6 to 6½	567±12	97±9	17.1±1.5	
26	5 to 5½		456±10	77±7	16.9±1.6	+0.5842±0.0871
		6 to 6½	508±12	90±8	17.7±1.7	
35	5 to 5½		477±12	106±9	22.2±1.8	+0.7325±0.0356
		6½ to 7	556±9	140±11	25.2±2.0	
36	5½ to 6		457±9	83±7	18.2±1.4	+0.4092±0.0936
		6½ to 7	509±12	106±8	20.8±1.7	
24	5½ to 6		510±18	131±13	25.7±2.5	+0.7768±0.0546
		7 to 7½	573±17	124±12	21.6±2.1	
34	6 to 6½		494±10	86±7	17.4±1.4	+0.5946±0.0748
		7 to 7½	549±11	93±8	16.9±1.4	
23	6 to 6½		523±16	116±12	22.2±2.2	+0.8116±0.0480
		7½ to 8	549±18	126±13	23.0±2.3	
25	6½ to 7		452±13	97±9	21.5±2.1	+0.6592±0.0763
		7½ to 8	519±14	105±10	20.2±1.9	
19	7 to 7½		489±12	79±9	16.1±1.8	+0.3731±0.1332
		8 to 8½	510±15	95±10	18.6±2.0	

Average coefficient of correlation, 0.6071.

0.4, and four are over 0.2; making nine over and seven below 0.5. The breed requirements excluded 145 cows from reëntry at lower than their initial records, and of the remaining 436 cows, 107, or 24.5 per cent, failed to exceed their initial records when retested. All groups have an average coefficient of correlation of 0.5021.

Of a total of 68 groups of animals for the three breeds, only 2 have correlation coefficients exceeding 0.8; 12 are over 0.7; and 49 are above and 19 below 0.5. The 19 groups below 0.5 include 750 of the total of 3674 cows. Thirty-five of the 68 groups have correlation coefficients less than 0.6. The grand average correlation coefficient is +0.6011.

Table 4 shows the distribution of the groups according to their correlation coefficients.

There is a slight tendency for the correlations to decline as the lapse of time between initial and retest records increases. However, there are not enough groups in all ages to make this tendency very pronounced.

TABLE 3

Correlation coefficients of initial and reentry milk records made by Ayrshire cows at various ages

NUMBER OF COWS	INITIAL RECORD AGE	REENTRY RECORD AGE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	COEFFICIENT OF CORRELATION
	years	*years*	*pounds*	*pounds*		
58	2 to 2½		8189±136	1532±96	18.7±1.2	+0.6015±0.0565
		3 to 3½	9577±178	2010±126	21.0±1.3	
48	2 to 2½		9080±202	2073±143	22.8±1.6	+0.5658±0.0663
		3½ to 4	10441±278	2861±197	27.4±1.9	
32	2 to 2½		8251±213	1789±151	21.7±1.8	+0.2917±0.1090
		4 to 4½	10734±222	1866±157	17.4±1.5	
50	2 to 2½		8499±172	1808±122	21.3±1.4	+0.4808±0.0733
		4½ to 5	11783±255	2676±180	22.7±1.5	
78	2½ to 3		9272±128	1679±91	18.1±1.0	+0.6083±0.0481
		3½ to 4	10172±151	1979±107	19.5±1.1	
56	2½ to 3		9569±174	1928±123	20.1±1.3	+0.5782±0.0600
		4 to 4½	10736±208	2310±147	21.5±1.4	
45	2½ to 3		9015±170	1687±120	18.7±1.3	+0.2503±0.0375
		4½ to 5	11003±183	1820±129	16.5±1.2	
38	2½ to 3		8930±169	1536±119	17.2±1.3	+0.2632±0.0338
		5 to 5½	11700±286	2605±201	22.3±1.7	
30	2½ to 3		8710±162	1320±115	15.2±1.3	+0.0826±0.0391
		6 to 6½	12456±296	2407±209	19.3±1.7	
30	3 to 3½		9167±204	1659±144	18.1±1.6	+0.6345±0.0735
		4 to 4½	10556±235	1912±166	18.1±1.6	
25	3 to 3½		9751±253	1878±179	19.3±1.8	+0.5792±0.0896
		4½ to 5	11151±324	2402±229	21.5±2.1	
20	3 to 3½		8914±212	1405±150	15.8±1.7	+0.2530±0.0543
		5½ to 6	11986±396	2623±280	21.9±2.3	
18	3½ to 4		9549±279	1753±190	18.4±2.1	+0.5746±0.1065
		4½ to 5	10961±321	2016±227	18.4±2.1	
16	3½ to 4		9583±249	1479±176	15.4±1.8	+0.5358±0.1202
		5 to 5½	10379±247	1468±175	14.1±1.7	
16	4 to 4½		9463±242	1433±171	15.1±1.8	+0.4138±0.1397
		5 to 5½	10423±278	1646±196	15.8±1.9	
21	4 to 4½		10024±363	2465±257	24.6±2.6	+0.6445±0.0861
		5½ to 6	11613±442	3002±312	25.9±2.7	

Average coefficient of correlation, 0.5021.

While the correlation coefficients constitute the most significant of the calculated data of this study, it will be seen that there is a markedly greater variability among the reëntry records than among the initial records. In only 18 of the 68 groups the coefficient of variability of the reëntry records exceeded that of the initial records; and only 5 groups had greater standard deviations for the reëntry than for the initial records. This may be in part due to the action of breed entry requirements, as they set only a low limit for entry, which does not offset the greater upward range of productive ability that comes with increasing age. There is no other significance shown in the coefficients of variability, and

TABLE 4

Distribution of correlation coefficients of initial and reentry records of cows of various breeds

CORRELATION COEFFICIENT RANGE	GUERNSEY	JERSEY	AYRSHIRE	TOTAL
+0.8000 to 0.8999	1	1		2
0.7000 to 0.7999	6	6		12
0.6000 to 0.6999	6	9	4	19
0.5000 to 0.5999	4	7	5	16
0.4000 to 0.4999	1	6	2	9
0.3000 to 0.3999	1	4		5
0.2000 to 0.2999			4	4
0.1000 to 0.1999				
0.0000 to 0.0999			1	1

for the entire lot they will average close to 20 per cent, with approximate limits of 15 per cent and 25 per cent.

If the original premise is correct, that the free action of heredity alone would result in correlation coefficients of plus one between initial and reëntry records made by the same cows at corresponding ages, then the fact that only 2 of 68 groups in this study have correlation coefficients above 0.8, only 12 others above 0.7, and that 33, or less than half, are above 0.6, while 19 are under 0.5, would seem to indicate that environment has acted to reduce the value of official records as material for studying inheritance of milk and butterfat production. The average correlation of all groups is 0.6071. It might be added that in 443, or 15 per cent, of a possible 2973 cases, the reëntry record did not exceed the initial record.

SWEETENED CONDENSED MILK

V. RANCIDITY*,[1]

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At the time when we gave evidence of the presence of lipase in milk (1), the statement was made that rancidity in sweetened condensed milk is in all probability due to the action of that enzyme; it reaching the manufactured product through the accidental admixture of unheated milk. Data here presented is in support of that conclusion.

The term "rancidity" is here taken to mean the flavor resembling butyric acid. Recently in the discussion of milk products this seems to be the common understanding of the term; such flavors as tallowy, fishy and metallic being carefully distinguished. The rancid flavor is due to butyric acid and perhaps other low molecular weight fatty acids, which result probably always from the hydrolytic splitting of the milk fat.

Rancidity in condensed milk is a defect fortunately not very common, but most serious when it does occur since the flavor is so penetrating and disagreeable that a rancid batch withdrawn from the trade cannot be used in candy making nor any other way as food.

The flavor once observed is never forgotten. It appears usually not before the product is ten days old. In the early stages the flavor of the milk itself may be satisfactory and only by making it up with some hot beverage is the taste noticeable. However, it rapidly becomes worse and in thirty to sixty days the penetrating odor of butyric acid is noted immediately on opening the can. The product becomes gradually more viscous and finally solid; and the acidity increases.

Samples representing about 20 commercial batches of rancid

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[1] Much of the work here recorded was carried on in coöperation with the Nestles Food Company of New York.

condensed milk were obtained for laboratory experimentation. The ages of some of the samples were unknown but most of them were two to four months old. On these samples a large number of analyses were made, both biological and chemical; the following observations only seemed significant: The acidity was always high; the bacterial count usually relatively low; and the peroxidase test in almost every case, positive. Table 1 gives the

TABLE 1

SAMPLE	ACIDITY	PEROXIDASE TEST	BACTERIAL COUNT
1	0.892	Strong	
2	1.035	Strong	<500
3	0.954	Strong	
4	1.143	Weak	500
5	1.260	Strong	31,000
6	1.032	Strong	70,000
7	1.125	Strong	<500
8	1.332	Strong	<500
9	0.567	Strong	11,000
10	0.540	Very strong	3,800
11		Very strong	1,700
12	0.882	None	
13	0.792	None	<500
14	0.530	Weak	250
15	0.600		500
16	0.360	Strong	300
17	0.470		500
18	1.017	Strong	
19	0.520	Strong	
20	0.820	Strong	

results obtained. Acidity was determined by titrating a diluted sample with alkali and calculating results in terms of lactic acid. Bacterial counts were made on agar plates.

At first sight it might appear that the condition of rancidity is similar to that of bacterial thickening which was described in the first paper of this series (2), but this is not the case. The acidity does rise in bacterial thickening but usually not so high as in rancidity; in both cases the product becomes thick and gradually

solid. But millions of bacteria are present in the former case, and the differences in flavor are unmistakable.

THE PRODUCTION OF RANCIDITY EXPERIMENTALLY

The fact that the rancid flavor of butyric acid would most likely be produced through the lipolytic splitting of butter fat, the fact already demonstrated that raw milk normally contains lipase, and the fact that peroxidase is found in most of the commercial samples of rancid condensed milk, strongly point to the possibility that rancidity is due to the accidental incorporation of unheated milk in the batch.

Experiments were carried out in two general ways: (*a*) manufacture of small batches in an experimental vacuum pan and (*b*) making various additions to normal condensed milk of factory manufacture. Samples were held in regular factory tin cans, one being opened at each time an inspection was to be made. The fact that each analysis is on a different sample explains in part why some of the analyses are rather divergent, particularly the bacterial counts.

EXPERIMENTAL BATCHES CONTAINING SMALL PERCENTAGES OF RAW MILK

A vacuum pan was used of about 400 pounds capacity. It was equipped so that the usual conditions of factory operation could be exactly duplicated. The hot well was equipped for heating the milk by injecting live steam. Unless otherwise stated the milk was brought to a boil in the hot well and the sugar dissolved in it; immediately, then, drawing of milk into the pan was begun. The temperature of condensation was always between 130 and 140°F.

Experiment 1

Batch A. Whole milk 250 pounds, sugar 46 pounds. After all the milk was in the pan, 5 pounds of unheated milk was drawn in.

Batch B. Carried out in a similar manner. Whole milk 170 pounds, sugar 30 pounds, cold unheated milk 13 pounds.

Batch C. Whole milk 170 pounds, sugar 30 pounds, unheated milk 19 pounds.

Batch D. Whole milk 186 pounds, sugar 31 pounds, no unheated milk.

Complete data on these batches is given in table 2. The samples on which the determinations were made had been kept at room temperature; a few were incubated at 98°F. for observation as to the speed in which the rancid flavor developed.

TABLE 2

	BATCH A	BATCH B	BATCH C	BATCH D
Per cent of unheated milk	2	7	10	0
Per cent of total solids in finished batch	74.00	74.56	75.33	75.45
Peroxidase test	Fair	Strong	Very strong	None
Acidity (per cent):				
Beginning	0.351	0.342	0.360	0.342
End of 10 days	0.396	0.342	0.432	
End of 20 days	0.414	0.405	0.477	0.342
End of 30 days	0.450	0.513	0.486	0.315
End of 60 days	0.490	0.570	0.540	0.360
End of 4 months	0.510	0.560	0.640	0.300
Bacterial counts:				
End of 5 days	4000	7500	63,000	4500
End of 17 days	2400	3300	22,000	
End of 27 days	4500	3400	9,600	
End of 37 days	2500	2500	6,600	11,200
End of 47 days	1100	1170	2,300	
End of 3 months				3200
End of 5 months	850	950	450	
Time of appearance of the rancid flavor:				
Incubated samples	10 days	10 days	10 days	Not in
Room temperature samples	30 days	30 days	10 days	6 months

Excepting the samples from the check batch (*D*) a gradual increase in acidity was noted in all cases and a flavor developed exactly like that of the rancid commercial samples previously described. Also the peroxidase test was always given. The general decrease in bacterial counts found here is not different from the behavior of normal condensed milk. Apparently those bacteria which contaminate the product at the time of manufac-

ture find it an unfavorable medium and all die out except a few species that are resistant to the high concentration of sugar.

The evidence presented to this point together with that to follow is sufficient to warrant the conclusion that rancidity in sweetened condensed milk results from the action of the lipase of raw milk on the butter fat; the liberation of free fatty acids, at least in part, causes the increase in acidity; those of lower molecular weight being the cause of the disagreeable odor.

These results show that the increase in rancidity can be meas-

TABLE 3

	RAW MILK ADDED							
	0 per cent		1 per cent		2 per cent		4 per cent	
	I*	R†	I	R	I	R	I	R
Acidity (per cent):								
Beginning	0.28	0.28	0.28	0.28	0.28	0.28	0.26	0.26
End of 30 days		0.28	0.43	0.36	0.48	0.42	0.56	0.49
End of 60 days	0.31		0.43		0.48		0.58	
End of 3 months	0.33			0.43		0.51		0.81
End of 6 months				0.62		0.52		0.82
Rancidity:								
End of 30 days	0	0	+		+		++	
End of 60 days	0	0	+	0	++	+	+++	+
End of 3 months	0	0		++		++		+++

* Incubated = I.

† Room temperature = R.

+ indicates moderate rancidity; +++ strong; 0 none. Blank spaces indicate that no observations were made.

ured at least in a rough quantitative way by the increase in acidity. For this reason the acidity of samples is given also in the remaining experiments.

ADDITIONS OF RAW MILK TO NORMAL CONDENSED MILK

Experiment 2

A quantity of condensed milk was obtained from a factory batch shortly after manufacture. To portions of this were added 1 per cent, 2 per cent, and 4 per cent of raw milk. One portion was

kept without any addition as a check. Samples were held both at incubator and room temperatures.

Table 3 gives the changes in acidity and the time of appearance of the rancid flavor. These results show that 1 per cent of raw milk is sufficient to cause rancidity at incubator temperature in thirty days and at room temperature in three months. The larger additions caused a more rapid development of the flavor. The acidity figures are in line with the inspections for flavor, very marked increases taking place except in the check. The very slight increase noted in the check sample is similar to that usually observed when normal condensed milk becomes old particularly when stored at higher than normal temperatures. As these results show, however, the acid increase in rancid samples is so much more rapid than in the check sample that there is no danger of confusion.

THE AMOUNT OF UNHEATED MILK NECESSARY TO PRODUCE RANCIDITY

Experiment 3

To different portions of normal condensed milk was added 0.1 0.5, 0.75, and 2 per cent of raw milk. In table 4 will be found the results of titration for acidity and of inspection for flavor.

Five-tenths per cent raw milk did not produce rancidity in four months, neither was lipolytic activity indicated by titration. However, in samples to which 0.75 per cent raw milk had been added, rancidity occurred of such degree as should prove objectionable to the trade. Of course, 2 per cent raw milk acted much more rapidly. The smallest amount found necessary to produce rancidity (0.75 per cent) calculated on the basis of the original whole milk in the sample would be equal to 0.3 per cent, considering the condensation to be $2\frac{1}{2}$ times. This shows even more how powerful is the effect of a little unheated milk. On a batch of 20,000 pounds of milk to produce rancidity would be required only 60 pounds of raw milk—much less than one can!

TEMPERATURE REQUIRED TO DESTROY LIPOLYTIC ACTIVITY

Experiment 4

To different portions of normal condensed milk were added 3 per cent portions of whole milk which had been exposed to different heat treatments as follows:

Series A. Milk was brought to the temperature indicated and cooled at once—(1) 170°, (2) 160°, (3) 150°, (4) 140°F.

Series B. Milk was brought to the temperature indicated,

TABLE 4

	PER CENT RAW MILK							
	0.10		0.50		0.75		2.00	
	I*	R†	I	R	I	R	I	R
Acidity (per cent):								
Beginning	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320
End of 20 days	0.342		0.324		0.378		0.414	
End of 35 days	0.351		0.423		0.495		0.522	
End of 75 days	0.370		0.390				0.510	
End of 4 months		0.310		0.340		0.380		0.460
End of 5 months		0.310		0.360		0.430		0.490
End of 9 months		0.360				0.400		0.550
Rancidity:								
End of 20 days	0		0		0		+	
End of 35 days	0		0		?		+	
End of 75 days	0		0		+		++	
End of 4 months		0		0		++		++

* Incubated = I.

† Room temperature = R.

held for fifteen minutes, then cooled—(1) 170°, (2) 160°, (3) 150°, (4), 140°, (5) 130°, (6) 120°F.

Sample C. As check, no heat treatment.

Of series A, no. 4 only became rancid. The increase in acidity in eight months at room temperature was from 0.30 to 0.43 per cent; under the same conditions the check sample increased to 0.59, which indicates that there was some destruction of lipase even at that temperature.

Among those of series B, nos. 1, 2, 3, and 4 did not become ran-

cid. Number 5 was rancid in four months, and 6 in two months.

The results indicate that heating for an instant at 150°, or, for fifteen minutes at 140° is sufficient to destroy lipase activity. It may be mentioned that on one occasion an entire batch was prepared by heating the milk at 145°—thirty minutes when no randicity developed.

This data gives some idea of the heat exposure necessary for the destruction of lipase. More exact figures were not obtained because it was believed that they would not prove to be useful, since conditions in the factory cannot well be duplicated in the laboratory. The next experiment shows how much, indeed, the conditions may influence the resistance of this enzyme to heat.

EFFECT OF THE PRESENCE OF SUGAR ON THE TEMPERATURE REQUIRED TO DESTROY LIPOLYTIC ACTIVITY

On several occasions samples of condensed milk containing some raw milk were heated to 180° for thirty minutes for the purpose of killing the lipase, but not always with success. This led to some experiments to learn whether or not the sugar had a protective influence.

Experiment 5

Two portions of raw milk containing 35 per cent cane sugar were heated and cooled at once: (1) to 170°, (2) to 185°F. These were added to condensed milk in 3 per cent proportions. Samples of series 1 became rancid in thirty days, those of series 2 not in six months.

Experiment 6

To a quantity of condensed was added 6 per cent of raw milk; this was divided into three portions: (1) no treatment, (2) heated to 180° for ten minutes, (3) heated to 200° for ten minutes. Samples of 1 and 2 became rancid in thirty days, those of series 3 not in six months; at the end of four months series 1 had increased in acidity from 0.27 to 0.64 per cent and series 2 from 0.28 to 0.54, indicating practically no lipase destruction at 180° ten minutes.

These results may be compared with those obtained in experiment 4, where it was found that by heating raw milk alone to 150° for an instant was sufficient to destroy the lipolytic power. From this it is evident that in the presence of sugar (or perhaps where less moisture is present), there is a protection of the enzyme from destruction by heat.

LIPOLYTIC POWER OF OLD MILK COMPARED WITH FRESH. THE RELATION OF BACTERIA TO RANCIDITY

Experiment 7

To two portions of condensed milk fresh raw milk was added in the proportions of 1.5 and 2.5 per cent. The remainder of the

TABLE 5

	Condition of raw milk			
	Fresh		3 days old	
	Per cent added		Per cent added	
	1½	2½	1½	2½
Acidity (per cent):				
Beginning	0.28	0.28	0.29	0.29
End of 30 days	0.38	0.46	0.31	0.41
End of 60 days	0.51	0.57	0.43	0.54
Rancidity:				
End of 30 days	0	++	0	0
End of 60 days	+	++	0	++

sample of raw milk was allowed to stand at room temperature for three days when it had curdled. Then another series of samples was prepared exactly like the first.

Table 5 gives the results of titrations for acidity and inspections for rancidity. It is shown there that the power of old milk to produce rancidity is no greater than that of fresh milk; in fact, it seems to be even less.

Throughout these experiments no direct evidence has been presented to support the contention that it is a lipase natural in milk which causes rancidity and that it is not due to a strain of organisms always present in raw milk. In all such cases as this,

it is extremely difficult to present any evidence other than indirect; and there is no question but that every one of the experiments here recorded point to the conclusion that it is an enzymic effect; a lipase natural in milk and not one produced by organisms. The experiment just described, does, indeed, support that conclusion: If the rancidity-producing power of raw milk were due to bacteria always present therein, the effect of aging should be to greatly increase that power; but the opposite was found to be the real state of affairs. Of course, there can be no increase in the amount of natural lipase, present in milk, the only quantitative change that can take place would be that its activity might be reduced in time.

On the assumption that in some special cases rancidity might possibly be produced through bacterial action, a large number of experiments were carried out.

A sample of raw milk was plated out under both aerobic and anaerobic conditions. Cultures of all organisms were grown in sterile milk. A commercial sample of rancid condensed milk was plated out and handled similarly. All cultures were added to condensed milk with the result that rancidity was produced in no case. The sample of raw milk, however, from which the first series of cultures was made produced rancidity when tested by the methods already described.

Also batches were prepared in the experimental vacuum pan using milk which had first been sterilized then inoculated with bacteria from the above-mentioned and other sources and a large number of molds. In no instance did rancidity develop.

ATTEMPT TO FIND OTHER CAUSES OF RANCIDITY

By running experimental batches and through additions to normal condensed milk the following were also eliminated as causes of rancidity: Applying excessive heat to milk or cream before running the batch, condensing at extremely high pan temperatures, use of sour milk neutralized with sodium bicarbonate, freezing the milk used in the batch, addition of various oxidation and hydrolytic products of fat, addition of salts of iron, copper, tin, zinc and hypochlorous acid.

Batches have been known to become rancid in which the content of cane sugar was so high that it crystallized out, also rancid batches were prepared in which the total solids was more than 77 per cent. But batches of low sugar and low solids content became rancid just as readily.

In fact 70 batches and numerous samples prepared in various ways are not described in this report. In not a single instance was there any indication that there is another cause of the typical butyric acid-like rancid flavor than through the action of a lipolytic enzyme which was found to be present in all the specimens of raw milk on which there was occasion to experiment.

RANCIDITY PRODUCTION BY THE ACTION OF PANCREATIC LIPASE

A suspension in water of commercial pancreatin was added to normal condensed milk in such a proportion that about 0.2 per cent of the pancreatin powder was present. The acidity of the mixture at the beginning was 0.30 per cent; at the end of forty days at room temperature 1.43 per cent, and at six months 2.73 per cent. Samples became gradually thicker and finally solid as was always found in rancid samples, and the odor was exactly that of rancid condensed milk as it is invariably found.

SUMMARY

1. Rancidity here refers to that flavor resembling butyric acid.

2. Commercial samples of rancid condensed milk were found to run relatively high in acidity and in most cases to give the peroxidase test. The viscosity was higher than in normal condensed milk; in some cases the product was solid.

3. Experimental batches of condensed milk prepared under usual conditions except that a little raw milk was allowed to enter the pan while the batch was being condensed invariably became rancid. The defect was more marked, the more raw milk present.

4. The addition of unheated milk to normal condensed milk always produced rancidity, as little as 0.75 per cent being effective.

This is equivalent to 0.3 per cent of the amount of whole milk from which the batch was prepared.

5. Heating whole milk to 140°F. for fifteen minutes, or 150° for an instant, was found sufficient to destroy lipolytic power. However, when sugar was present, or, where attempts were made to destroy lipase in condensed milk, a considerably higher temperature was required.

6. Milk three days old had no more power to produce rancidity than fresh milk. This is presented as a point of evidence that this power is not due to any bacteria that might be present.

In further support of this contention an experiment was carried out in which cultures of all organisms isolated from raw milk failed to produce rancidity when incorporated in normal condensed milk, though the raw milk itself did have the power to do so. Cultures of organisms isolated from rancid condensed milk also failed to produce rancidity.

Sterile whole milk inoculated with these and other cultures, then condensed down in the usual way did not produce rancid batches.

7. Various metallic salts and other chemicals and various mechanical treatments of milk did not cause rancidity. Its production was independent of solids or sugar content.

8. Pancreatic lipase added to condensed milk was shown to produce the rancid flavor, increase the acidity and viscosity exactly as did raw milk.

THEORETICAL CONCLUSIONS

1. The cause of rancidity in condensed milk is the accidental incorporation of raw milk in the batch. The activity of the raw milk is due to the presence naturally of a lipolytic enzyme, which splits the milk fat yielding among other fatty acids those of low molecular weight such as butyric, to which the rancid flavor is due.

2. Data given here may be considered further proof of the presence of lipase in milk in addition to that already presented by us (1).

3. The importance of considering milk products with this point

in mind is again emphasized. Rancidity (butyric acid-like flavor) in cream and milk, butter and cheese may well be attributed to this enzyme.

4. It is common knowledge that the best milk products can be manufactured only from good fresh milk. Bacterial action may not be the only factor entering here. When the milk is old, lipase and perhaps other hydrolytic enzymes have time to produce small amounts of substances which may later lower the quality of the manufactured product. The work of Holm and Greenbank (3) at Washington has shown that the free fatty acids increase the oxidizability and consequent tallowiness of fats. The most likely source of fatty acids is from the lipolytic splitting of fat.

PRACTICAL CONCLUSIONS

1. The contamination causing rancidity is most likely to take place through raw or improperly heated milk being accidentally drawn into the batch at the time of condensation.

2. The great danger of rancidity is shown by the fact that only 0.3 per cent of unheated milk in a batch may cause this defect.

3. The temperature under which a vacuum pan ordinarily operates (130 to 140°F.) is not sufficient to destroy the rancidity-producing power of raw milk. Hot well temperatures used in common practice (180°–boiling) are sufficient; though 180°F. is a dangerous temperature when much sugar or condensed milk has been added to the hot well.

4. Two variations from good factory operation that might make rancidity possible are: (*a*) Leaky intake valves through which a small amount of milk from an unheated hot well might be drawn into a pan under operation, and (*b*) carelessness in heating the hot well so that all the milk does not reach the temperature necessary to destroy the enzyme. The latter possibility would include the dangerous practice of pouring a few cans of cream or milk into a hot well which at the same time is being drawn into the pan.

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(1) Rice and Markley: Jour. Dairy Sci., 1922, v, 64.
(2) Rice and Downs: Jour. Dairy Sci., 1923, vi, 532.
(3) Greenbank and Holm: Jour. Ind. Eng. Chem., 1924, xvi, 598.

JOHAN D. FREDERIKSEN

News has just been received of the death of Mr. J. D. Frederiksen at St. Petersburg, Fla., on February 19, 1926. Mr. Frederiksen was for many years vice-president and general manager of Chr. Hansen's Laboratory, Little Falls, N. Y., having retired from active business in the fall of 1924. He was born at Fuglsang, Lolland, Denmark, August 18, 1846. His father was an expert farmer who at one time conducted eight large estates, two of which he owned. His mother was the daughter of a minister named Hansen.

He attended school in Soro where he lived in the home of Professor Johnstrup, later graduating from the agricultural college in Copenhagen in 1866. A few years later, he and his brother Christian attempted to introduce sugar beet raising in Denmark. Production began in 1872. Then came the "Black Friday" on the New York Stock Exchange precipitated by Jay Gould. The effect was disastrous even in Denmark, and ruined the two brothers financially. Later, however, Mr. Frederiksen was decorated for his activity in this work with the Order-Dannebrog by the Danish King.

He made a new start in coming to New York as a representative of the Chr. Hansen Laboratory on November 9, 1877. Here he developed the laboratory at Little Falls, and later at Toronto and Milwaukee. His knowledge of milk led him to develop "Junket," his outstanding achievement, well known to every housewife. His business activities made him known and respected throughout the dairy industry of America, and his frequent visits to the parent laboratory in Copenhagen kept him in touch with his homeland.

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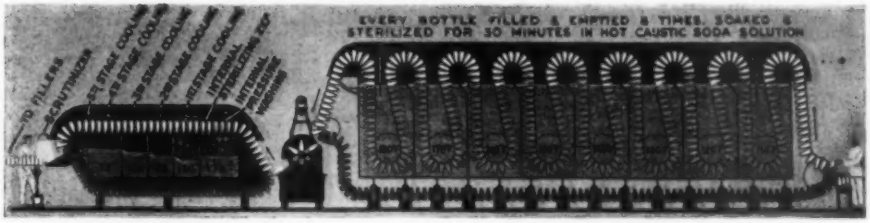

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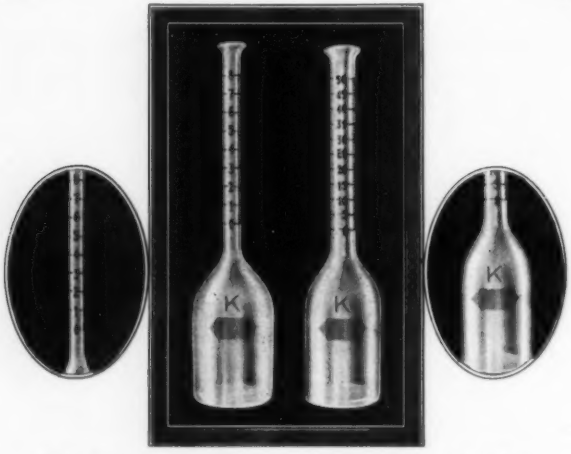

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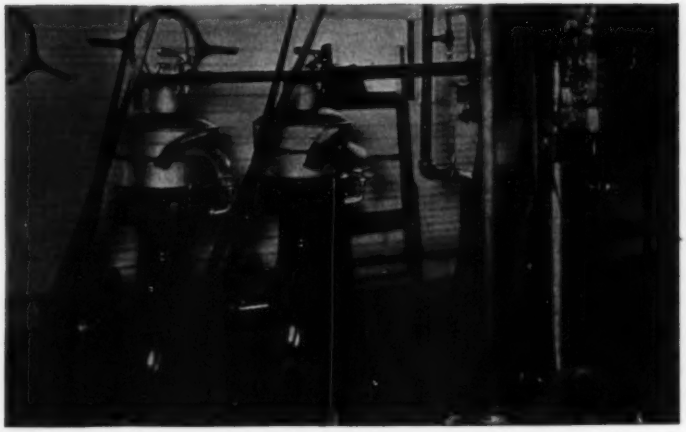

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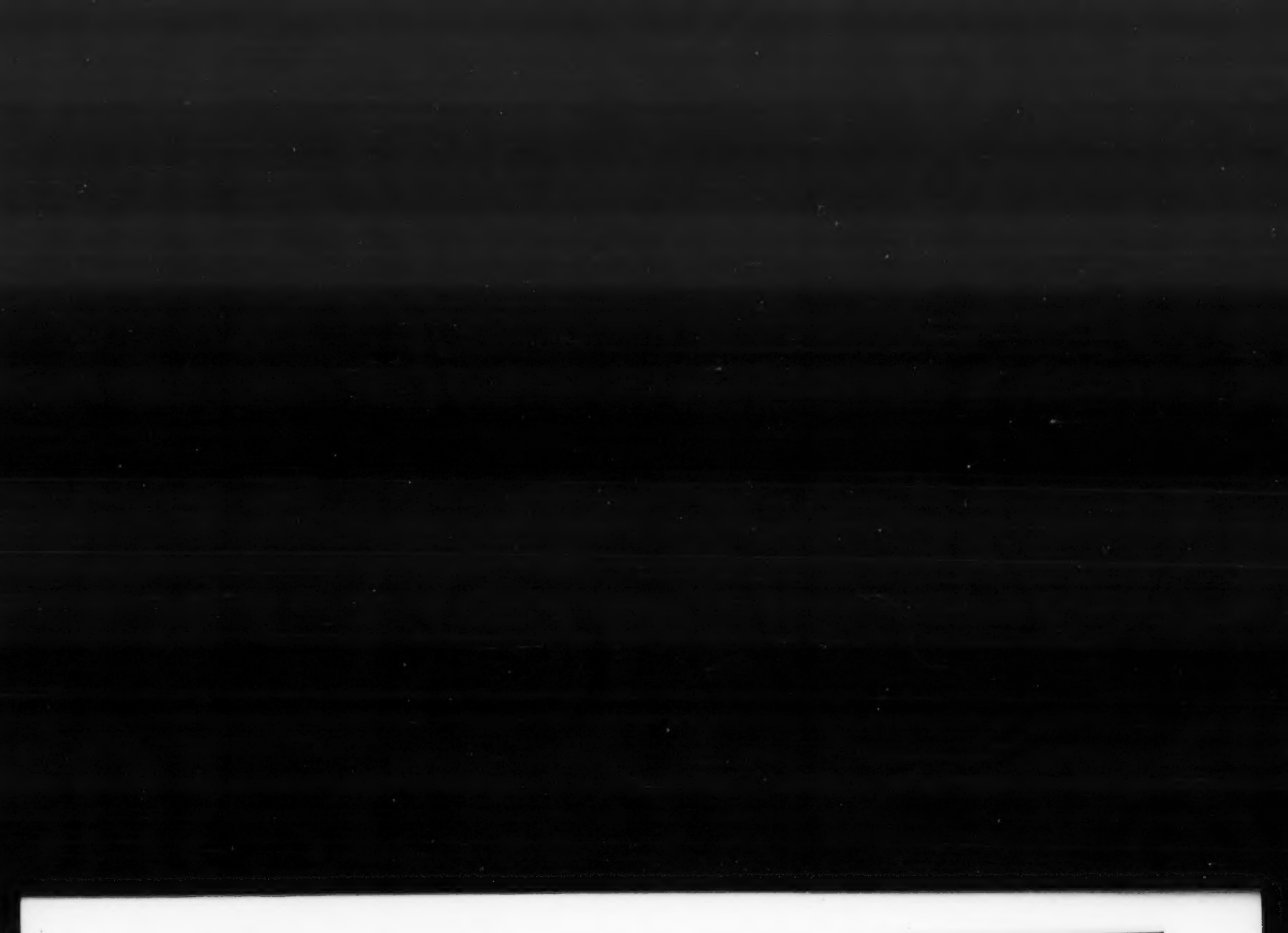

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Dehydrated Culture Media

for the Study of the Lactobacillus Group

PEPTONIZED MILK AND PEPTONIZED MILK AGAR

These media contain the unconverted lactose and the digested proteins, albumins and globulins of milk.

WHEY BROTH AND WHEY AGAR

The milk albumins and some unconverted lactose are retained in these media which are specially suited for the cultivation of Lactobacillus bulgaricus.

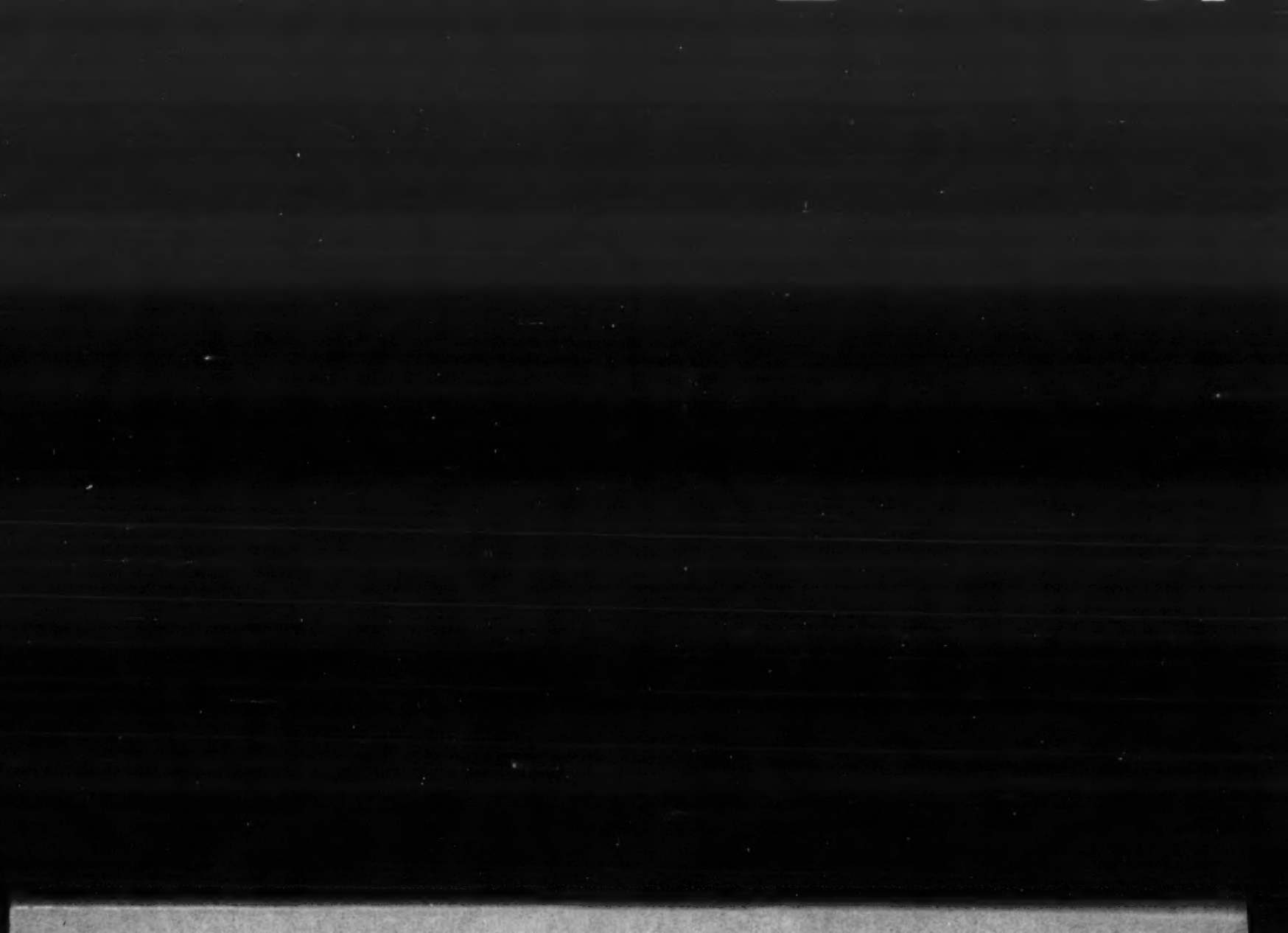
NUTRITIVE CASEINATE AGAR

A differential medium for the plate counts of milk, distinguishing acid and peptonizing colonies on one plate.

Specify "DIFCO"

THE TRADE NAME OF THE PIONEERS

In the research and development of Basic-Peptone and Dehydrated Culture Media

Digestive Ferments Company

DETROIT, MICHIGAN, U. S. A.